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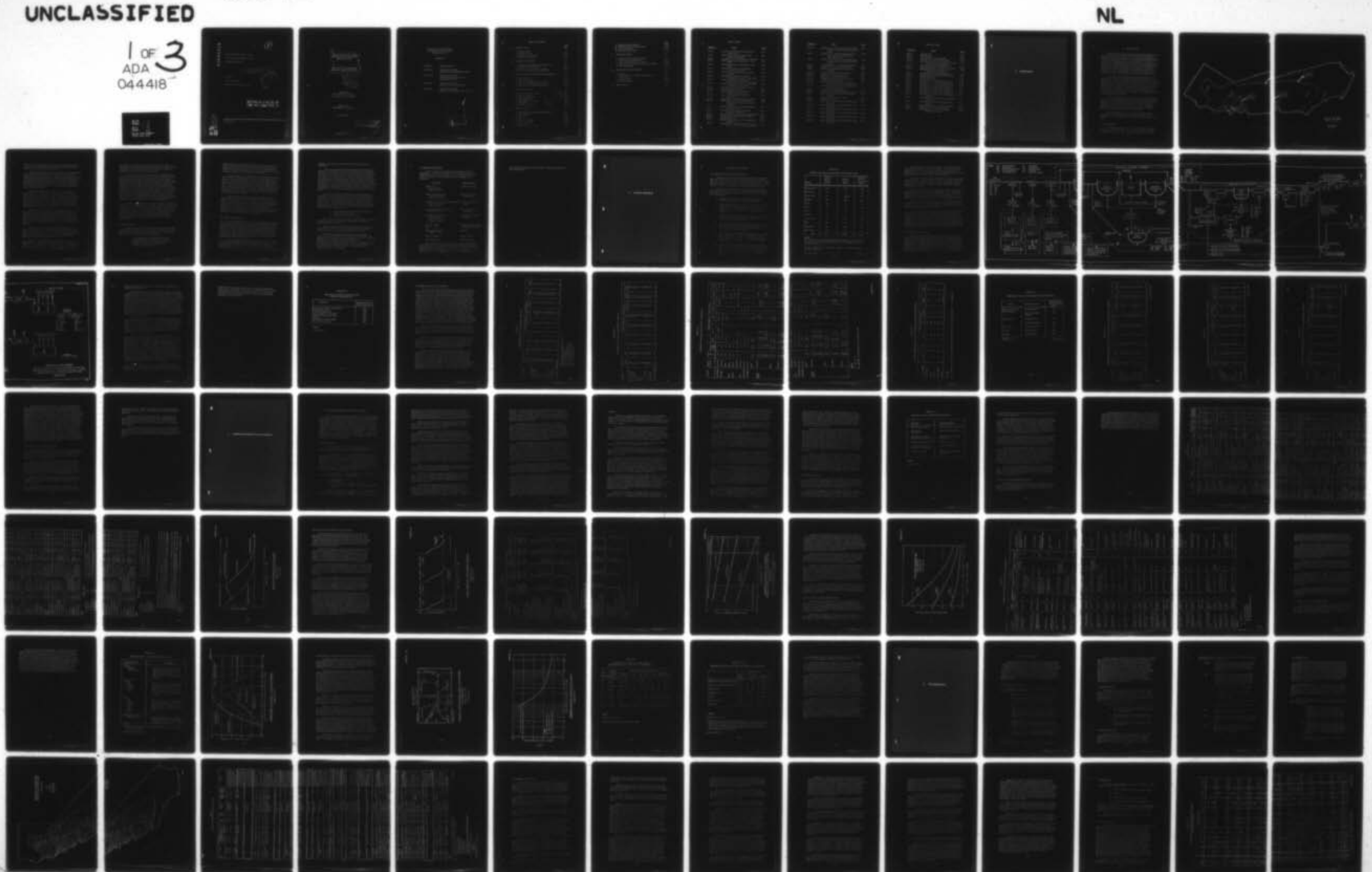

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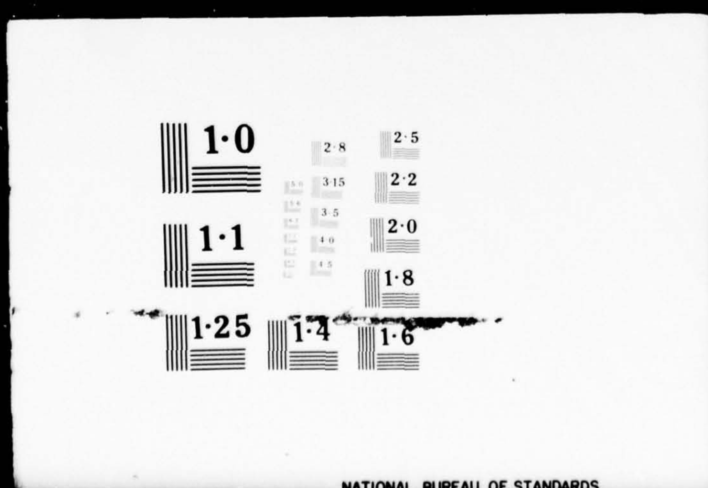

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THE SAN FRANCISCO BAY - DELTA

WASTEWATER AND RESIDUAL SOLIDS

MANAGEMENT STUDY

VOLUME II

Technical Appendix

Wastewater Management Studies

PBQ&D, Inc.
San Francisco

(6)

The San Francisco Bay - Delta Wastewater and Residual Solids Management Study.

Volume II. Technical Appendix Wastewater Management Studies.

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The San Francisco-Bay-Delta
Wastewater and Residual Solids
Management Study

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A. INTRODUCTION

A. INTRODUCTION

Animal and human waste products have for many centuries been put to beneficial uses in many parts of the world, particularly in Central Europe, China and Japan. These uses have included burning and application to agricultural lands for crop nutrient and soil amendment value. With the advent of water operated waste collection systems and centralized waste treatment plants, sewage by-products became less accessible and less valuable to individuals because of their lower concentration of nutrients. In addition, an increased awareness of public health problems discouraged any reuse without stringent controls. Consequently the collection and treatment of waste products have created disposal problems of major proportions.

In the United States, this problem chain was fostered by short-term economic policies and a surplus of clean water, clear air and unused lands available for outright dumping of treatment plant residues. Greater attention to environmental considerations during the past decade, accompanied by a decline in available natural resources, has brought about a renewed interest in the potential reuse of all by-products that were previously considered to be only suitable for disposal. The short-term economic policies previously applied to confined areas are being replaced with much broader, environmentally based considerations of feasibility for regional areas.

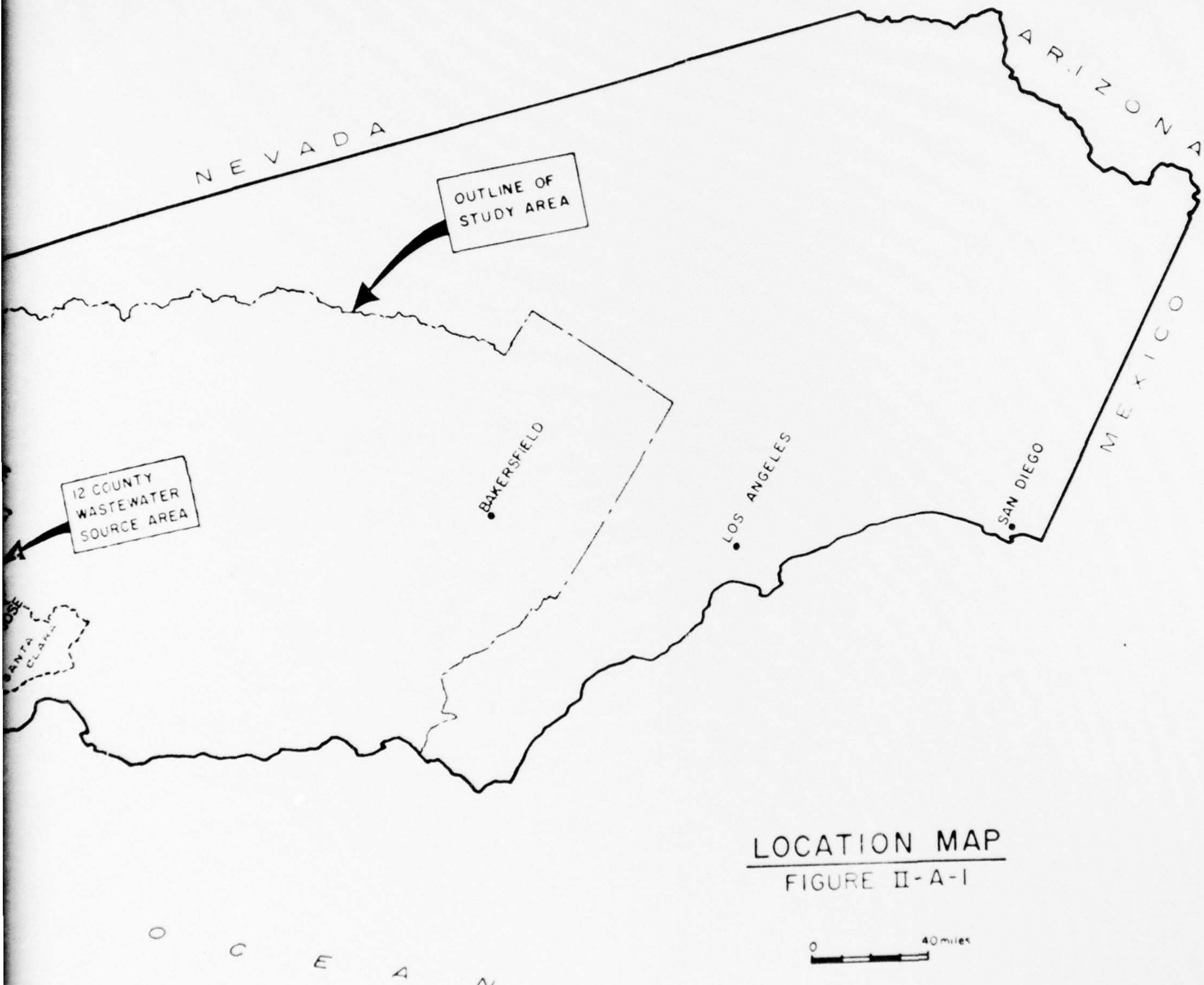
Within this overall context, the Pilot Wastewater Management Program of the Corps of Engineers has been conceived in five metropolitan regions throughout the United States: the Boston Region in the Merrimack River Basin, the Detroit Region in seven river basins draining into Lake Erie, the Cleveland-Akron Region, the Chicago Region in several watersheds draining into the south end of Lake Michigan and the San Francisco Bay - Delta Region.

This report presents the results of the investigations of extensive land sites (5,000 acres or greater) identified as being suitable for receiving wastewater from the San Francisco Bay - Delta Region.

1 - The Study Area

The Study Area selected is shown in Figure II-A-1 and encompasses the 70,000 square mile region extending from the Cascade Mountains in the north to the Tehachapi Mountains in the south and

OREGON
NEVADA
REDDING
SACRAMENTO
STOCKTON
12 COUNTY
WASTEWATER
SOURCE AREA
SANTA ROSA
SAN JOSE
SAN FRANCISCO
SOLANO
CONTRA COSTA
ALAMEDA
SANTA CLARA
P A C I F I C
O C E A



LOCATION MAP

FIGURE II-A-1

(1)

from the Sierra Nevada Mountains in the east to the Pacific Ocean in the west. It includes 39 counties and five hydrologic sub-regions having climates ranging from arid to maritime.

The water resources of the western slopes of the central portion of the Coast Range Mountains and of San Francisco Bay and its principal tributaries, the Sacramento and San Joaquin Rivers, have supported the development of one of America's most prosperous regions. This prosperity has been achieved through imaginative development, management and utilization of these water resources in combination with continuing expansion of land resource use. The San Francisco Bay - Delta Region has become one of the five largest metropolitan areas in the United States.

The water resources of the Study Area support a large and highly successful economy based on the irrigation of over seven million acres of agricultural crops. The irrigated area is expected to grow to about nine million acres by the year 2020 if adequate water supplies can be developed. The gradual deterioration of the quality of available water, particularly groundwater, is of great concern throughout the Study Area. Increased uses of upstream waters and introduction of concentrated return flows have lowered the quality of water available to many downstream users.

Maintenance of the existing level of prosperity in these areas with future developments will require continuing exercise of the imaginative resource development and management activities of the past. The timely need and corresponding public concern for comprehensive and innovative new concepts in resource development and management clearly demand that new programs demonstrate consideration for values not considered within traditional resource development programs.

Among these values are those associated with protecting and improving our environment. The water resources of San Francisco Bay, the Sacramento and San Joaquin Rivers, and the Delta support many unique and important natural resources of regional and national interest. Protection of these resources has resulted in a continuing effort to effectively manage wastewaters from all sources.

Among the steps resulting from this concern has been an effort, reflected through national, state and local policies and construction programs, to improve the quality of treated municipal and industrial wastewaters prior to discharge into receiving bodies. This effort has led to a broad consideration of municipal and industrial wastewaters

as a resource potentially suitable for diverse uses in a variety of locations. Consideration of wastewater as a usable resource reflects an attention to economic and environmental objectives within the context of modern comprehensive planning goals.

Continued efforts to raise the efficiency and performance of present waste treatment processes to meet or exceed projected water quality standards will require substantial increments in capital, operation and maintenance costs. Prior to commitment to these costs, evaluation of a wide range of alternative wastewater management and treatment systems is needed. One of the least explored of these systems is use of the earth's soil mantle to accomplish wastewater treatment objectives equivalent or superior to those achievable by the installation and operation of sophisticated additions to conventional treatment plans. Substantial benefits, represented by reductions in waste treatment costs, may accompany such a system. Of major interest are also the additional benefits which may accrue to the land sites through increased productivity and the additional opportunities for further recovery and beneficial reuse of the wastewater.

The concept of wastewater reuse offers a number of attractive opportunities for environmental enhancement. Maximum use of natural processes to accomplish purification of wastewater is in keeping with the goal of management of all resources--air, land and water--as a total recirculating system. Opportunities for environmental benefits include the release of presently committed higher quality water resources for higher levels of use and the elimination of environmentally undesirable overdrafts of existing resources in water deficient areas.

2 - Previous Studies

In July 1971, the Corps of Engineers, San Francisco District, completed a feasibility report titled "Alternatives for Managing Wastewater in the San Francisco Bay and Sacramento - San Joaquin Delta Area" (Ref. 2). The objectives of the study were:

> "... to consider the problem of regional wastewater management; to investigate the opportunity offered by regional wastewater management; and to explore the need for a subsequent more detailed study of the problem."

The conclusions of the feasibility report have set the stage for this study to identify and evaluate specific land sites where secondary waste treatment plant effluent could be constructively applied in a manner that would not endanger any of the parameters of environmental quality and could, in fact, enhance the environment.

Over 130 land sites in California are now being used for wastewater reclamation and these sites produce an annual volume of about 46 billion gallons (140,000 acre-feet per year) of reclaimed water (Ref. 1). Seventeen of these sites are located in the 12-County Bay - Delta Region and 70 are located in the combined Study Area of this report. Thus the concepts and methods of applying wastewater to land sites for reclamation purposes are not new. The scale of the application envisioned and the regional framework in which land application of wastewater has been studied in this report, however, exceed the scopes of any previous studies.

Many studies of proposed and constructed water resource development projects have been made in the Study Area by various federal, state, regional and local agencies. Those projects situated in or near any of the selected sites are discussed in the Site Identification section of this report. The availability of data from these studies ranges from published reports to unconsolidated files. Although a considerable effort was made in this investigation to gather all pertinent existing data, there are some less prominent and less readily accessible data which have not been used.

3 - General Study Approach

There are extensive land areas in the Study Area which, although requiring long conveyance facilities, must be considered as potential sites for wastewater application. From a practical standpoint, however, only a limited number of sites could be given meaningful evaluations and it was necessary to identify those sites which are representative of much larger areas. Using this approach, on-site factors such as unit application and recovery rates, unit costs and potential benefits can be made to apply with some qualification to areas that were not selected for the more detailed study.

A screening method based on exclusionary criteria was applied to the 70,000 square mile Study Area to eliminate a large portion of the area from further consideration for sites. This screening process resulted in the identification of 53 potential sites, from which nine sites were selected for further study on the basis of their representative

qualities, accessibility, soil suitability and other comparative advantages.

The nine representative sites selected for further evaluation represent a broad range of alternatives for application of wastewater to lands in the Study Area rather than just the lowest cost alternatives. Four of the sites selected (Sites 5, 12, 27 and 43) will probably be more expensive to develop from the technical engineering standpoint but are expected to provide primary economic benefits to the land with secondary benefits to the environment. Three sites (Sites 4, 18 and 21) were selected to represent the opportunity for primary environmental enhancement with some secondary economic benefits. Only two of the sites (Sites 28 and 42) were selected because they are near major wastewater sources and thus will approach a minimum cost of development.

The characteristics and distribution of each dominant soil association occurring in the nine selected sites were identified and vegetative covers recommended for each. The four general categories of vegetative cover recommended are forests on the steep uplands, pasture grasses on the terraces and uplands, general crops on the basins and alluvial fans, and marsh type grasses on the alluvial fans used for high-rate applications. Three limiting rates of wastewater application are given as follows:

1. Soil application and infiltration capacity limit
2. Vegetation survival limit
3. Vegetation optimum growth limit

The resulting rates of water recovery and groundwater recharge are presented for three alternative combinations of land use and wastewater application rates.

Potential methods and problems in developing and managing a typical watershed of a site were investigated as well as probable ranges in unit area costs and gross crop economic values.

A baseline environmental assessment of fish, wildlife, recreation and public health based on available published data and judgments was carried out for the selected sites. Future environmental studies required and their relative importance were identified for each of the sites. Some of the more obvious changes in environmental conditions with future wastewater application to the sites are identified and, where needed, potential mitigation of undesirable effects is discussed.

4 - Technical Consultants

Recognizing the need for specialized expertise and local experience in a wide range of engineering and environmental areas, a team of Special Technical Consultants was organized at the outset of this investigation. The consultant team was composed of the following:

Consultant	Technical Areas
PBQ&D, Inc. Paul H. Gilbert Harold K. Creed	General Consultant
Kennedy Engineers, Inc. Robert M. Kennedy William A. Anderson	Water Quality and Public Health
Harding, Miller, Lawson and Associates Richard S. Harding Frank C. Boerger	Geology and Ground Water
Jones & Stokes Associates, Inc. Charles M. Hazel	Fish, Wildlife and Recreation
San Francisco Bay Marine Research Center Curtis L. Newcombe Herbert L. Mason	Overall Environmental Analysis
James W. Biggar James N. Luthin	Soils, Vegetation, Water Quality and Drainage
Stone and Associates Edward C. Stone	Forestry
Robert M. Hagan	General Review
P. H. McGauhey	General Review

The consultant team participated in two general meetings during the initial phase of the investigation. Based on these meetings, six reports were prepared on site evaluation criteria. All of the consultants contributed site evaluation materials that have been incorporated directly into Volumes I, II and III and their unedited materials have

been assembled in Volume IV of this report. Their work is also cited in the Bibliography.

B. AVAILABLE WASTEWATER

B. AVAILABLE WASTEWATER

1 - Present and Projected Wastewater Flows

The present and projected average annual flows of wastewater from each of the 12 counties of the Study Area are given in Table II-B-1. The total projected flow (1.6 billion gallons per day or about 1.8 million acre-feet per year) is substantial, and, if collected at one point, would provide a significant contribution to California's total water supply.

Considering typical rates of water utilization, the estimated volumes of wastewaters originating in the Study Area in the year 2000 (1.8 million acre-feet per year) would be sufficient to satisfy any one of the following uses:

a. Supply of annual irrigation water demand of between 300,000 and 600,000 acres of agricultural land.

b. Supply of sufficient process water annually for a number of large industrial complexes composed of high water using industries. One such industrial use could be adequate cooling water for 60,000 megawatts of thermal generating capacity.

c. Supply of the annual requirements of 300,000 acres of wetland area within the Pacific Flyway used for wintering habitat and production of waterfowl.

d. Enhancement of between 0.5 and 1.8 million acres of land with native vegetation to diversify vegetal cover, thereby improving the character of the landscape of these areas and creating new wildlife habitats.

e. Provide from 0.4 to 0.9 million acre-feet of water annually for the augmentation of flows in a number of moderately large streams to create or enhance aquatic communities in these streams and to provide water-oriented recreational opportunities.

f. Supply of 1.8 million acre-feet of water annually to the Sacramento-San Joaquin Delta and Suisun Bay for flushing, to arrest the intrusion of salt water and to relieve the major storage reservoirs in the valley of the demand to deliver over one million acre-feet of higher quality water for this purpose.

Table II-B-1

PRESENT AND PROJECTED MUNICIPAL WASTEWATER FLOWS

County	Present Average Flow 1/ (MGD)	Design Flow 1/ (MGD)	Projected Flow for Year 2000 2/ (MGD)
San Francisco	120	166	130
San Mateo	65	91	98
Santa Clara	160	200 3/	350
Alameda	126	296	208
Marin	28	37	60
Sonoma	16	19	45
Napa	7	14	21
Solano	22	67	71
Contra Costa	61	87	347
Yolo	14	15	40
Sacramento	80	127	161
San Joaquin	34	68	77
Total	733	1087	1608

NOTES:

1/ From "Existing Municipal Wastewater Dischargers in the 12-County San Francisco Bay and Sacramento-San Joaquin Delta Region," Corps of Engineers (tabular data).

2/ From correspondence from Corps of Engineers and based on county population projections.

3/ Value estimated because data missing.

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The projected water quantity estimates, given in Table II-B-1, are based on the trends of several parameters. Population forecasts, land use projections, anticipated industrial growth and changes in industrial processes and wastewater treatment technology are all factors that can markedly affect the validity of these estimates.

Increases in the per capita household consumption of water will probably continue. Greater utilization of labor-saving home appliances such as automatic clothes washers, dishwashers and home garbage grinders will produce greater volumes of water, detergents and organic waste loads in sewage.

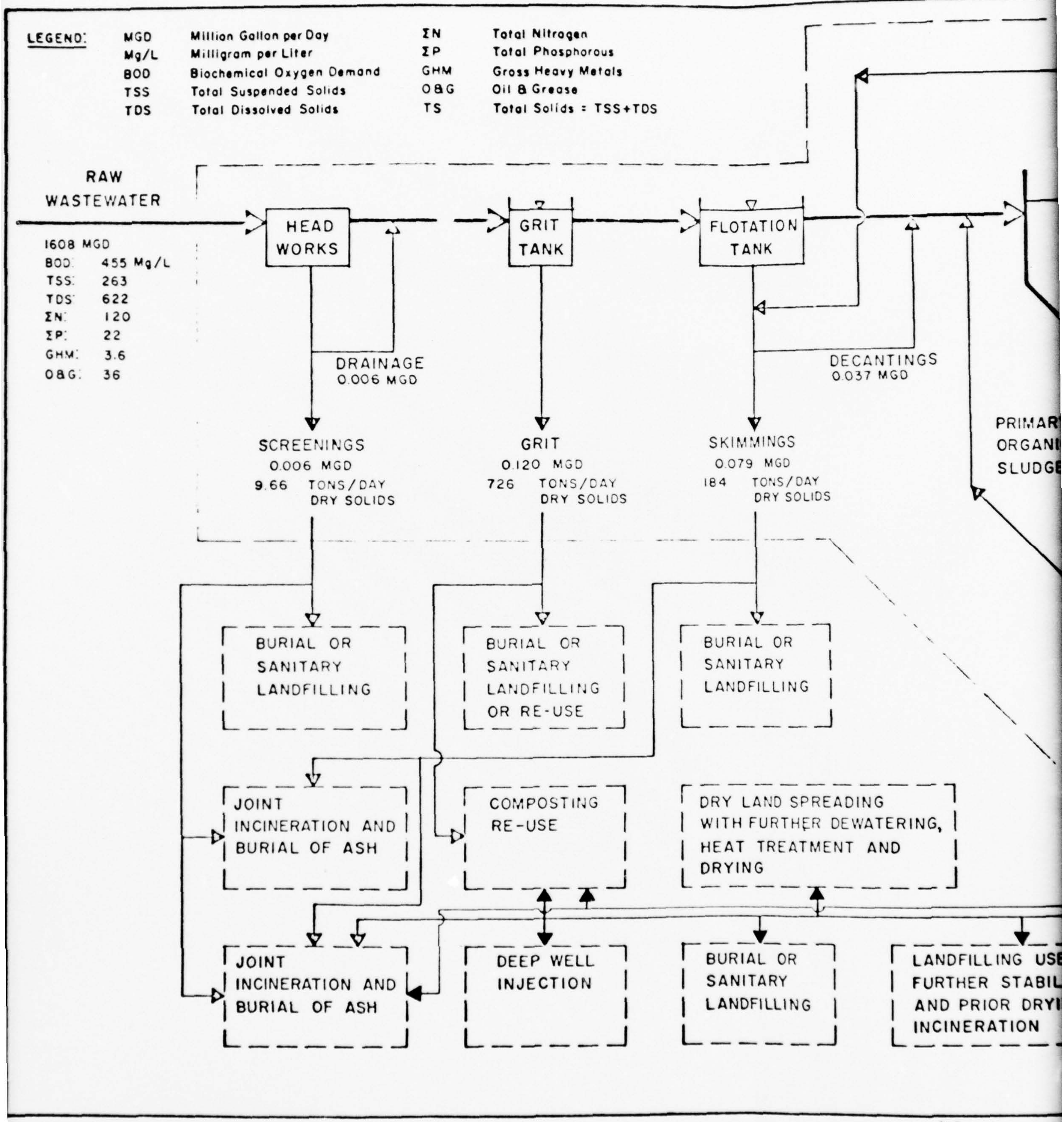
However, plumbing devices are available which could substantially reduce certain elements of household water usage. The British dual cycle water closet uses a 2.5 gallon flush for solids and 1.25 gallons for urine; the average flush tank volume in Sweden is less than three gallons. American fixtures require 5 to 6 gallons for each use.

The volume of industrial wastewaters can be controlled by reuse of wastewaters, separation of storm runoff and relatively clean non-process waters from process waste, changes in the industrial processes and through general conservation of water.

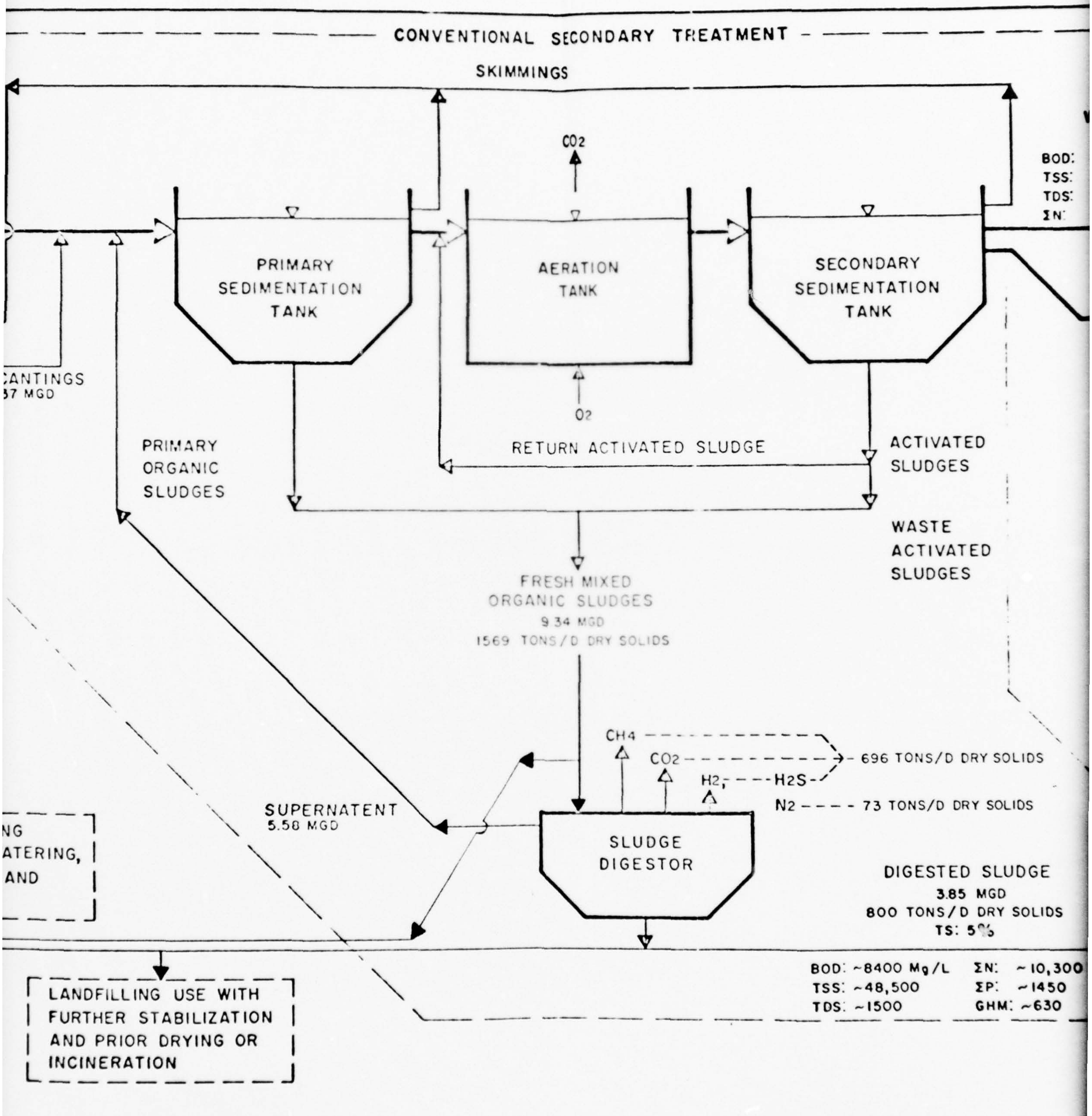
It has been assumed that in the year 2000 all non-process flows such as cooling water will be discharged directly into an estuary or other nearby body of water. Non-process water is usually of such quality that it may be discharged directly into neighboring waters with a minimum of on-site treatment. Since most of this non-process wastewater is cooling water, the only treatment necessary may be to cool it sufficiently to avoid thermal pollution. Non-process wastewaters could also be applied to land sites but would increase the size of wastewater treatment and conveyance facilities and land areas required.

2 - Projected Waste Treatment

All wastewaters including industrial wastewaters available to the regional collection and conveyance systems are assumed to have received standard or equivalent secondary treatment. Normal unit processes of secondary treatment are screening, sedimentation, primary skimming and clarification, aerated digestion of the wastewater, secondary clarification, sludge thickening and digestion and disinfection. In addition, industrial wastewaters are assumed to have been sufficiently treated to be acceptable to a normal municipal waste treatment plant. Figure II-B-1 gives a conceptual flow diagram of the conventional

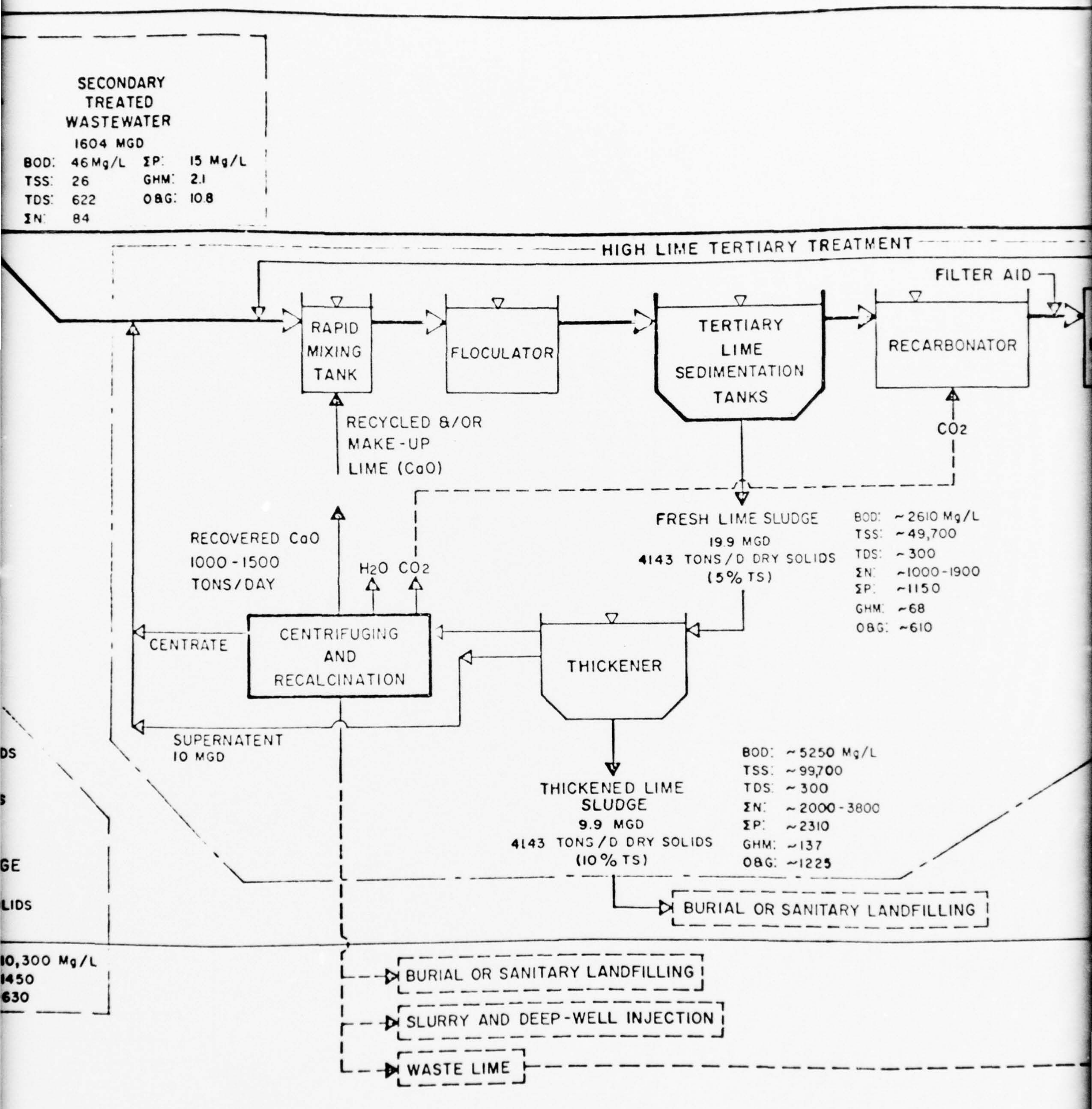


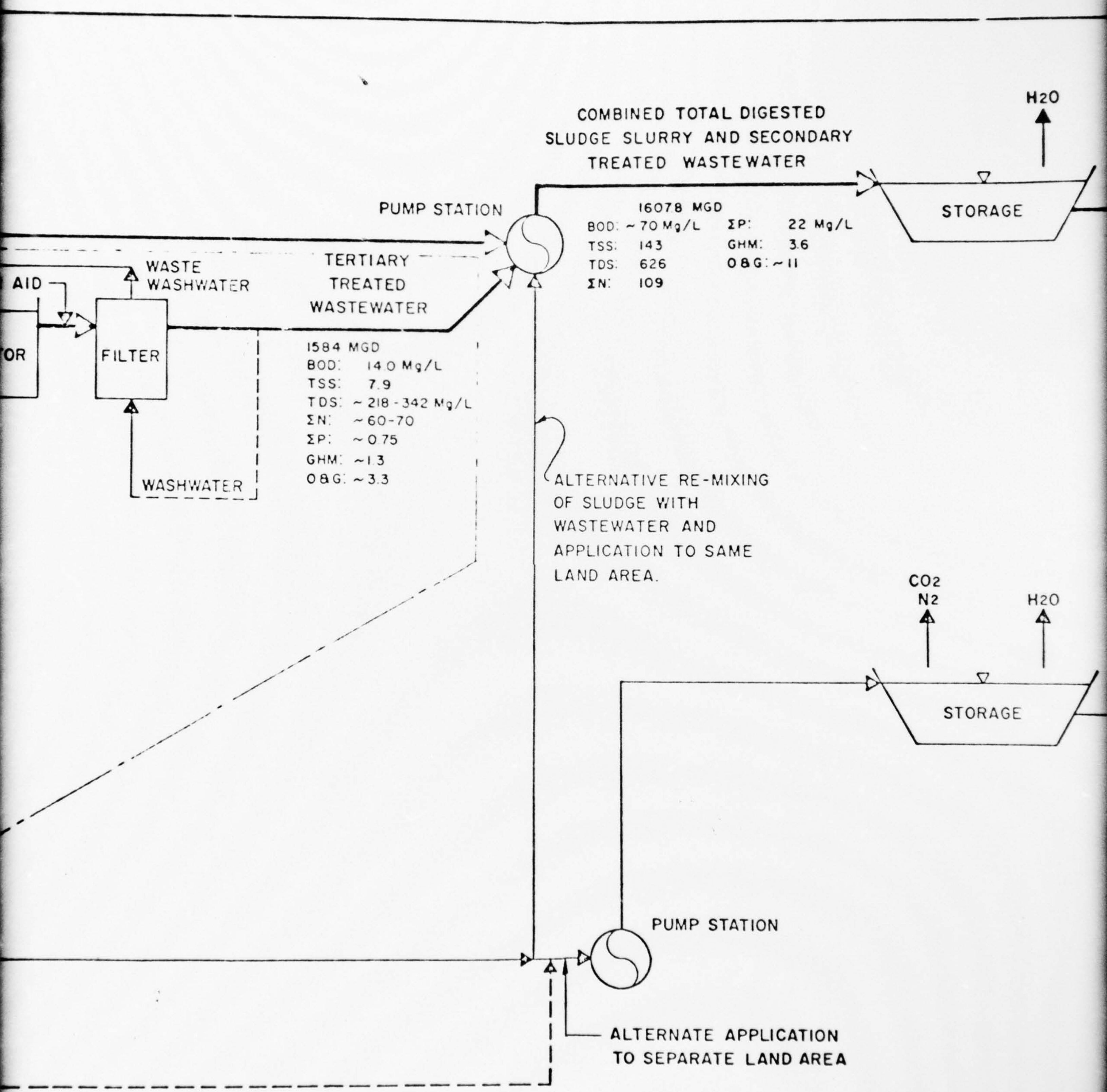
LEGEND:
MGD Million Gallon per Day
Mg/L Milligram per Liter
BOD Biochemical Oxygen Demand
TSS Total Suspended Solids
TDS Total Dissolved Solids
ΣN Total Nitrogen
ΣP Total Phosphorous
GHM Gross Heavy Metals
O&G Oil & Grease
TS Total Solids = TSS+TDS
RAW WASTEWATER
1608 MGD
BOD: 455 Mg/L
TSS: 263
TDS: 622
ΣN: 120
ΣP: 22
GHM: 3.6
O&G: 36
HEAD WORKS
GRIT TANK
FLOTATION TANK
DRAINAGE 0.006 MGD
DECANTINGS 0.037 MGD
SCREENINGS 0.006 MGD 9.66 TONS/DAY DRY SOLIDS
GRIT 0.120 MGD 726 TONS/DAY DRY SOLIDS
SKIMMINGS 0.079 MGD 184 TONS/DAY DRY SOLIDS
PRIMARY ORGANI SLUDGE
BURIAL OR SANITARY LANDFILLING
BURIAL OR SANITARY LANDFILLING OR RE-USE
BURIAL OR SANITARY LANDFILLING
JOINT INCINERATION AND BURIAL OF ASH
COMPOSTING RE-USE
DRY LAND SPREADING WITH FURTHER DEWATERING, HEAT TREATMENT AND DRYING
JOINT INCINERATION AND BURIAL OF ASH
DEEP WELL INJECTION
BURIAL OR SANITARY LANDFILLING
LANDFILLING USE FURTHER STABIL AND PRIOR DRYI INCINERATION



CONVENTIONAL SECONDARY TREATMENT
SKIMMINGS
CO2
BOD:
TSS:
TDS:
ΣN:
PRIMARY SEDIMENTATION TANK
AERATION TANK
SECONDARY SEDIMENTATION TANK
CANTINGS
37 MGD
O2
PRIMARY ORGANIC SLUDGES
RETURN ACTIVATED SLUDGE
ACTIVATED SLUDGES
WASTE ACTIVATED SLUDGES
FRESH MIXED ORGANIC SLUDGES
9.34 MGD
1569 TONS/D DRY SOLIDS
CH4
CO2
H2
H2S
696 TONS/D DRY SOLIDS
N2
73 TONS/D DRY SOLIDS
SUPERNATENT
5.58 MGD
NG
ATERING,
AND
SLUDGE DIGESTOR
DIGESTED SLUDGE
3.85 MGD
800 TONS/D DRY SOLIDS
TS: 5%
BOD: ~8400 Mg/L
TSS: ~48,500
TDS: ~1500
ΣN: ~10,300
ΣP: ~1450
GHM: ~630
LANDFILLING USE WITH FURTHER STABILIZATION AND PRIOR DRYING OR INCINERATION

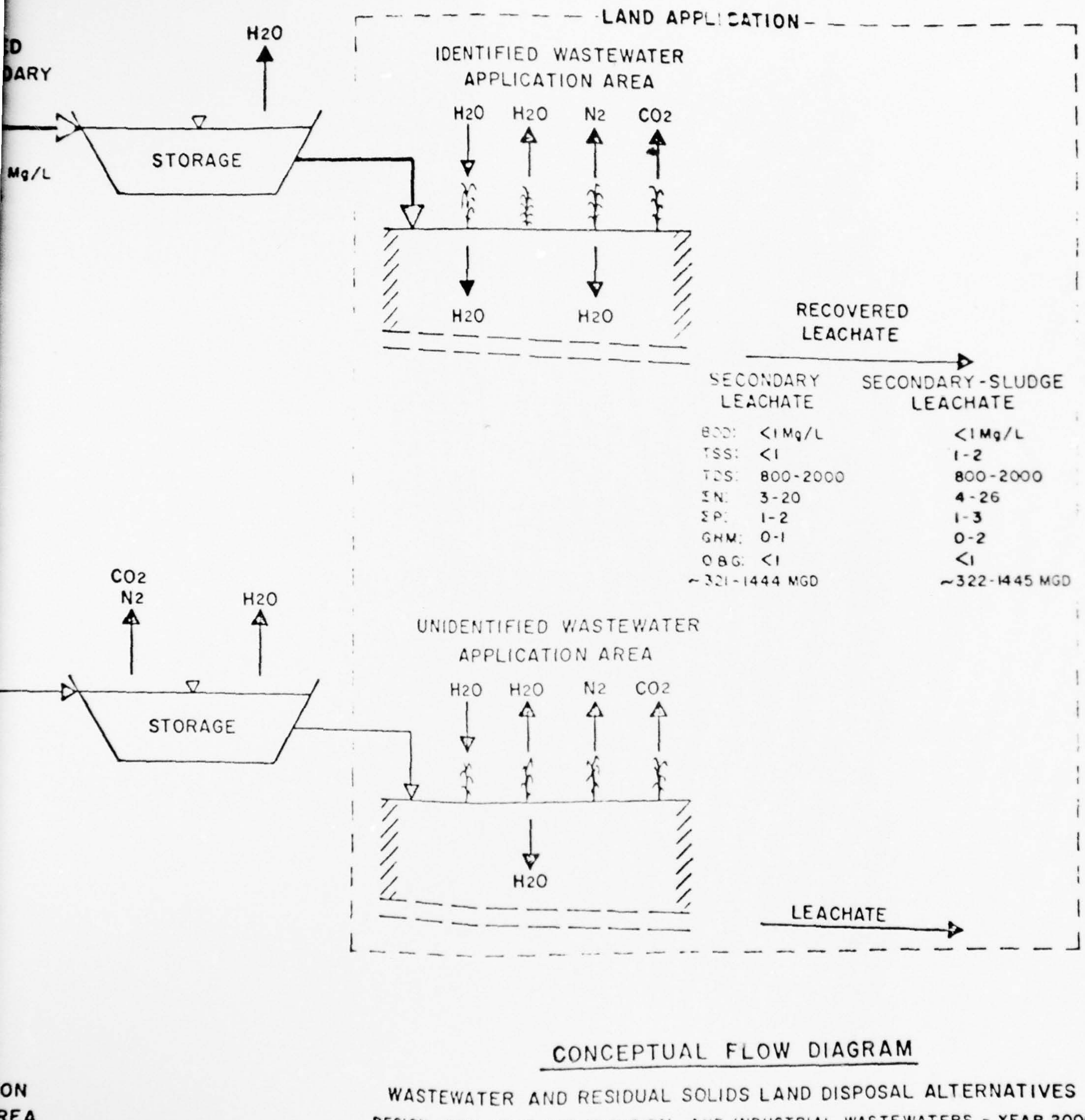
(1)


SECONDARY TREATED WASTEWATER
1604 MGD
BOD: 46 Mg/L
TSS: 26
TDS: 622
ΣN: 84
ΣP: 15 Mg/L
GHM: 2.1
O&G: 10.8
HIGH LIME TERTIARY TREATMENT
FILTER AID
RAPID MIXING TANK
FLOCULATOR
TERTIARY LIME SEDIMENTATION TANKS
RECARBONATOR
RECYCLED &/OR MAKE-UP LIME (CaO)
CO2
FRESH LIME SLUDGE
19.9 MGD
4143 TONS/D DRY SOLIDS
(5% TS)
BOD: ~2610 Mg/L
TSS: ~49,700
TDS: ~300
ΣN: ~1000-1900
ΣP: ~1150
GHM: ~68
O&G: ~610
RECOVERED CaO
1000-1500 TONS/DAY
H2O
CO2
CENTRATE
CENTRIFUGING AND RECALCINATION
THICKENER
SUPERNATENT
10 MGD
THICKENED LIME SLUDGE
9.9 MGD
4143 TONS/D DRY SOLIDS
(10% TS)
BOD: ~5250 Mg/L
TSS: ~99,700
TDS: ~300
ΣN: ~2000-3800
ΣP: ~2310
GHM: ~137
O&G: ~1225
BURIAL OR SANITARY LANDFILLING
BURIAL OR SANITARY LANDFILLING
SLURRY AND DEEP-WELL INJECTION
WASTE LIME
DS
GE
LIDS
10,300 Mg/L
1450
630



H2O
COMBINED TOTAL DIGESTED
SLUDGE SLURRY AND SECONDARY
TREATED WASTEWATER
PUMP STATION
STORAGE
16078 MGD
BOD: ~70 Mg/L
TSS: 143
TDS: 626
ΣN: 109
ΣP: 22 Mg/L
GHM: 3.6
O&G: ~11
WASTE
WASHWATER
TERTIARY
TREATED
WASTEWATER
AID
TOR
FILTER
1584 MGD
BOD: 14.0 Mg/L
TSS: 7.9
TDS: ~218-342 Mg/L
ΣN: ~60-70
ΣP: ~0.75
GHM: ~1.3
O&G: ~3.3
WASHWATER
ALTERNATIVE RE-MIXING
OF SLUDGE WITH
WASTEWATER AND
APPLICATION TO SAME
LAND AREA.
CO2
N2
H2O
STORAGE
PUMP STATION
ALTERNATE APPLICATION
TO SEPARATE LAND AREA

31



CONCEPTUAL FLOW DIAGRAM

WASTEWATER AND RESIDUAL SOLIDS LAND DISPOSAL ALTERNATIVES

REGION-WIDE COMBINED MUNICIPAL AND INDUSTRIAL WASTEWATERS - YEAR 2000

(BASED ON CONVENTIONAL ACTIVATED SLUDGE TREATMENT SYSTEM)

Figure II-B-1

(4)

activated sludge treatment process and the alternative methods of handling waste products.

Table II-B-2 gives the average constituent removal coefficients expected for secondary waste treatment in the year 2000. The removal coefficient for total dissolved solids (0) assumes that there is an equal conversion of organic dissolved solids to suspended solids and of organic suspended solids to inorganic dissolved solids during the treatment process. The removal efficiencies cited in Table II-B-2 are consistent with current processes. It is expected that most plants that will be in operation in the year 2000 are plants now in operation or in the design or construction phases. Existing plants are expected to be upgraded to provide this degree of treatment, and plants in the design or construction phase will provide secondary treated effluents. It is also assumed that for plants that become overloaded the units built will maintain this standard of sewage treatment.

Existing plants are of the biologic treatment type. Physical-chemical treatment of wastewaters and tertiary treatment may be accomplished for select dischargers in the near future. However, the impact of these advances on the total volume of predicted wastewater availability will be rather limited in the Study Area before the year 2000. Therefore, the treatment plant effluents discussed in this section are considered to have been treated by conventional biological processes and disinfected to current standards.

It is assumed that disinfection will be accomplished to the point that there will not be a public health hazard. With a good secondary effluent, one that is highly clarified and oxidized, good control of microorganisms can be attained by chlorination. Numerous viruses are more resistant to chlorine than coliform bacteria (the standard indicator for bacterial pollution). Methods of using viruses as an indicator of chlorination efficiency with practical analysis for routine use are not yet available. Except for hepatitis, clearly defined outbreaks of viral diseases traced to waters have been rare. Advances in the area of disinfection of wastewaters include the use of ozone, which is widely used in Europe, and radiation. With advancements in detecting viruses and the application of new techniques of disinfection, it is expected that the public health hazard from microorganisms in the wastewaters will continue to be minor and controllable.

There are, however, standards limiting the use of sewage as irrigation water. The State of California Public Health Service requires a median MPN of 2.2/100 ml for spray irrigation of produce and a median MPN of 23/100 ml for irrigation of processed food crops (Ref. 11). Stan-

dards for other constituents are not given. In general, the regional water quality control boards judge waste discharge requests on a case by case basis and in terms of established objectives for use of the receiving waters. The boards have not in the past set water quality standards for irrigation water.

Table II-B-2

ESTIMATED SECONDARY TREATMENT PLANT
REMOVAL COEFFICIENTS 1/

Constituent	Estimated Removal Efficiency (percent)
Biochemical Oxygen Demand (BOD)	- 90%
Total Nitrogen (TN)	- 30%
Total Phosphorous (TP)	- 30%
Total Suspended Solids (TSS)	- 90%
Total Dissolved Solids (TDS)	- 0 -
Phenols	- 80%
Gross Heavy Metals (GHM)	- 40%
Oil and Grease (O&G)	- 70%

NOTES:

1/ From Ref. 2

3 - Projected Wastewater Constituents

The constituent data for treated municipal wastewater given in Table II-B-3 have been prorated according to the latest flow projections given in Table II-B-1. The untreated quantities in Table II-B-4 were obtained by applying the removal coefficients from Table II-B-2 to the municipal treated quantities in Table II-B-3. Table II-B-5 gives the individual breakdown of industrial waste constituents which have been grouped by counties using the code numbers given the industries in the Kaiser study (Ref. 3). Missing data has been supplemented by Table II-B-6 which has been averaged from the data reported by Brown and Caldwell Engineers in their study of Contra Costa County (Ref. 4). Use of these supplementary data is valid for Contra Costa County but there is some argument against their use for the other counties. There are differences in the water supply in each area and variations in the raw materials, processes and operation and maintenance programs within different plants in the same industry. These differences are responsible for the variations in wastewaters from similar industrial types at different locations. Table II-B-7 gives the variations in water quality supplied to the different municipalities and industries in the 12-county Study Area.

Because of the explainable variations in water quality and because the industrial flows in these areas are relatively small compared to the municipal wastewater loads, Table II-B-6 has been used to supplement the data in Table II-B-5 for the counties other than Contra Costa County.

Tables II-B-8 and II-B-9 consolidate the data in Tables II-B-4, II-B-5 and II-B-6. The values in Table II-B-10 are derived by applying the removal coefficients (Table II-B-2) to Table II-B-9 and represent the typical wastewater effluents that would be expected from a single facility that either provides standard secondary treatment or collects the effluents from county-wide secondary treatment plants.

A review of Table II-B-10 indicates the effect of industrial wastewaters on the quality of wastewaters from each county. Contra Costa County, because it is the industrial center of the area (65% of the total projected flow is industrial), is a striking example. The wastewater has very high concentrations of total dissolved solids (1,000 mg/l) and phenols (0.010 mg/l). In Napa County, as another example, wastewater is markedly influenced by only one major industry. This industry discharges less than 5 per cent of the total county flow but increases the average concentration of gross heavy metals (GHM) from about 1.2 mg/l to the 22.0 mg/l shown in Table II-B-10.

Table II-B-3

TREATED MUNICIPAL WASTEWATERS - YEAR 2000

COUNTY	FLOW (MGD)	CHARACTERISTIC - 1,000 lbs/day							
		BOD	TN	TP	TSS	TDS	Phenols	GHM	O&G
San Francisco	130	50	81	16	30	573	---	1.6	12
San Mateo	90	34	56	11	21	396	---	1.1	8
Santa Clara	350	133	218	44	80	1,540	---	4.3	31
Alameda	195	74	121	25	45	860	---	2.4	17
Marin	60	19	31	6	11	199	---	0.5	4
Sonoma	45	14	23	4	8	150	---	0.4	3
Napa	20	6	10	2	4	67	---	0.2	2
Solano	60	19	31	6	11	199	---	0.5	4
Contra Costa	120	40	66	9	24	460	---	1.3	9
Yolo	38	12	17	4	7	128	---	0.4	3
Sacramento	160	49	73	16	29	540	---	1.5	11
San Joaquin	45	14	21	4	8	152	---	0.4	3
Total or Average	1,313	66	108	22	40	763	---	2.1	15

BOD = Biochemical Oxygen Demand
TN = Total Nitrogen
TP = Total Phosphorus
TSS = Total Suspended Solids
TDS = Total Dissolved Solids
GHM = Gross Heavy Metals
O&G = Oil and Grease

Table II-B-4

UNTREATED MUNICIPAL WASTEWATERS - YEAR 2000

COUNTY	FLOW (MGD)	CHARACTERISTIC - 1,000 lbs/day							
		BOD	TN	TP	TSS	TDS	Phenols	GHM	O&G
San Francisco	130	500	115	23	300	573	---	2.7	40
San Mateo	90	340	80	16	210	396	---	1.8	27
Santa Clara	350	1,330	310	63	800	1,540	---	7.2	103
Alameda	195	740	173	36	450	860	---	4.0	57
Marin	60	190	44	9	110	199	---	0.8	13
Sonoma	45	140	33	6	80	150	---	0.7	10
Napa	20	60	14	3	40	67	---	0.3	7
Solano	60	190	44	9	110	199	---	0.8	13
Contra Costa	120	400	94	13	240	460	---	2.1	30
Yolo	38	120	24	6	70	128	---	0.7	10
Sacramento	160	490	104	23	290	540	---	2.5	37
San Joaquin	45	140	30	6	80	152	---	0.7	10
Total or Average	1,313	665	154	31	400	763	---	3.6	51

Table II-B-5

UNTREATED INDUSTRIAL WASTEWATERS - YEAR 2000 1/

County	Type of Industry	Code No. 2/	Process Flow (MGD)	CHARACTERISTIC - 1,000 lbs/day							
				BOD	TN	TP	TSS	TDS	Phenols	GHM	O&G
San Mateo	Chemical	529	7.7	1.26	0.0022	---	105.9	---	0.0022	---	0.74
Alameda	Chemical	423	12.2	0.81	0.311	8.58	25.10	---	---	0.177	0.311
	Paper	303	0.9	21.0	---	---	32.8	---	---	---	---
Napa	Metals	147	0.8	---	---	---	---	---	---	6.05	---
Solano	Metals	191	0.6	---	---	---	---	---	---	4.53	---
	Petroleum	173	10.3	144	45.8	---	---	---	0.017	0.286	17.2
Yolo	Cannery	---	2.3	7.7	---	---	3.7	11.7	---	---	---
Sacramento	Cannery	---	0.84	2.8	---	---	1.4	24.6	---	---	---
San Joaquin	Cannery	---	5.1	19.4	---	---	9.7	4.2	---	---	---
	Paper	715	15.1	30.3	---	---	46.6	---	---	---	---
		750	12.6	30.3	---	---	46.6	---	---	---	---
Contra Costa	Chemical	267	6.7	---	---	---	4.44	---	---	0.089	---
		272	11.9	0.44	7.03	---	48.8	---	0.0045	---	2.78
		273	4.1	6.88	1.70	---	1.33	---	0.0022	---	---
		204	5.04	9.03	77.7	2.78	---	---	---	0.170	0.81
		200	5.3	2.29	0.385	0.577	---	---	---	0.0385	0.231
		216	7.85	5.77	48.1	1.43	---	---	---	0.096	0.481
		266	5.48	---	---	---	---	---	---	---	---
	Paper	272	24.8	29.4	---	---	45.4	---	---	---	---
		273	20.6	50.5	---	---	108.4	---	---	---	---
		273	64.9	103.0	---	---	159.6	---	---	---	---
	Petroleum	229	15.0	208	66.6	---	---	---	0.025	0.416	25
		215	8.5	118.5	38	---	---	---	0.014	0.239	14.0
		203	29.2	406	134.2	---	---	---	0.049	0.811	48.9

	Petroleum	173	10.3	144	45.8	---	---	---	0.017	0.286	17.2
Yolo	Cannery	---	2.3	7.7	---	---	3.7	11.7	---	---	---
Sacramento	Cannery	---	0.84	2.8	---	---	1.4	24.6	---	---	---
San Joaquin	Cannery	---	5.1	19.4	---	---	9.7	4.2	---	---	---
	Paper	715	15.1	30.3	---	---	46.6	---	---	---	---
		750	12.6	30.3	---	---	46.6	---	---	---	---
Contra Costa	Chemical	267	6.7	---	---	---	4.44	---	---	0.089	---
		272	11.9	0.44	7.03	---	48.8	---	0.0045	---	2.78
		273	4.1	6.88	1.70	---	1.33	---	0.0022	---	---
		204	5.04	9.03	77.7	2.78	---	---	---	0.170	0.81
		200	5.3	2.29	0.385	0.577	---	---	---	0.0385	0.231
		216	7.85	5.77	48.1	1.48	---	---	---	0.096	0.481
		266	5.48	---	---	---	---	---	---	---	---
	Paper	272	24.8	29.4	---	---	45.4	---	---	---	---
		273	20.6	50.5	---	---	108.4	---	---	---	---
		273	64.9	103.0	---	---	159.6	---	---	---	---
	Petroleum	229	15.0	208	66.6	---	---	---	0.025	0.416	25
		215	8.5	118.5	38	---	---	---	0.014	0.239	14.0
		203	29.2	406	134.2	---	---	---	0.049	0.811	48.9
		266	13.8	192.5	614	---	---	---	0.023	0.385	22.9
	Metals	268	0.9	---	---	---	---	---	---	6.69	---
		227	1.05	---	18.1	---	---	---	---	0.181	---
		215	3.61	---	---	---	---	---	---	0.55	---
		211	0.14	---	---	---	---	---	---	1.01	---

NOTES:

1/ From Ref. 3

2/ See Ref. 3 for explanations of industrial codes

Table II-B-6

TYPICAL CHARACTERISTICS OF INDUSTRIAL PROCESS WASTEWATERS 1/

INDUSTRY	CHARACTERISTIC (mg/l)						
	TN	TP	TSS	TDS	Phenols	GHM	O&G
CHEMICAL	7	8	7	750	----	0.7	2.5
FOOD	3	0	500	8000	----	---	3.1
PAPER	---	---	210	1460	----	---	---
PETROLEUM	---	---	24	1160	----	0.55	22
METALS	1	0	50	700	----	2.19	6

NOTES:

1/ From Ref. 4. Values in this table are averaged from the values reported in Ref. 4. PBQ&D, Inc.

Table II-B-7

VARIATION IN QUALITY OF MUNICIPAL WATER SUPPLIES 1/

Utility	Source of Supply	Average Total Dissolved Solids (mg/l)
East Bay Municipal Utility District	Mokelumne River	50
	Upper San Leandro Reservoir	110
San Francisco	Tuolomne River	30
	Peninsula Reservoir	450
Sacramento	Sacramento River	120
San Jose	Local Supplies	260
Stockton	Local Supplies	280

NOTES:
1/ From Ref. 4.

PBQ&D, INC.

Table II-B-8

UNTREATED COMBINED MUNICIPAL AND INDUSTRIAL WASTEWATERS - YEAR 2000

COUNTY	FLOW (MGD)	CHARACTERISTIC - mg/l							
		BOD	TN	TP	TSS	TDS	Phenols	GHM	O&G
San Francisco	130	462	107	21	278	530	---	2.5	37
San Mateo	98	418	98	21	388	545	0.0027	2.2	34
Santa Clara	350	456	107	22	276	530	---	2.5	36
Alameda	208	441	100	26	294	548	---	2.4	33
Marin	60	380	88	18	220	398	---	1.6	26
Sonoma	45	374	88	16	214	402	---	1.9	27
Napa	21	343	80	17	230	411	---	36.0	40
Solano	71	565	152	15	186	510	0.029	9.5	51
Contra Costa	347	550	202	29	240	1000	0.052	5.0	47
Yolo	40	385	72	18	222	420	---	2.1	30
Sacramento	161	368	78	17	218	422	---	1.9	28
San Joaquin	77	344	47	10	286	768	---	1.1	16
Total or Average	1,608	455	120	22	263	622	---	3.6	36

PB Q&D, INC.

Table II-B-9

UNTREATED COMBINED MUNCIPAL AND INDUSTRIAL WASTEWATERS - YEAR 2000

COUNTY	FLOW (MGD)	CHARACTERISTIC - 1,000 lbs/day							
		BOD	TN	TP	TSS	TDS	Phenols	GHM	O&G
San Francisco	130	500	115	23	300	573	---	2.7	40
San Mateo	93	341	80	17	316	444	0.0022	1.8	28
Santa Clara	350	1,330	310	63	800	1,540	---	7.2	103
Alameda	208	762	173	45	508	947	---	4.2	57
Marin	60	190	44	9	110	199	---	0.8	13
Sonoma	45	140	33	6	80	150	---	0.7	10
Napa	21	60	14	3	40	72	---	6.3	7
Solano	71	334	90	9	110	302	0.017	5.6	30
Contra Costa	347	1,541	566	81	674	2,820	0.0145	14.0	132
Yolo	40	128	24	6	74	140	---	0.7	10
Sacramento	161	493	104	23	291	565	---	2.5	37
San Joaquin	77	220	30	6	183	492	---	0.7	10
Total or Average	1,608	871	245	44	480	1,249	---	6.1	70

PBQ&D, INC.

Table II-B-10

TREATED COMBINED MUNICIPAL AND INDUSTRIAL WASTEWATERS - YEAR 2000

COUNTY	FLOW (MGD)	CHARACTERISTICS - mg/l							
		BOD	TN	TP	TSS	TDS	Phenols	GHM	O&G
San Francisco	130	46	75	15	28	530	---	1.5	11.1
San Mateo	98	42	69	15	39	545	0.0005	1.3	10.2
Santa Clara	350	46	75	15	28	530	---	1.5	10.8
Alameda	208	44	70	18	29	550	---	1.4	9.9
Marin	60	38	62	13	22	400	---	1.0	7.8
Sonoma	45	37	62	11	21	400	---	1.1	8.1
Napa	21	34	56	12	23	410	---	22.0	12.0
Solano	71	57	106	11	19	510	0.006	5.7	15.3
Contra Costa	347	55	141	20	24	1000	0.010	3.0	14.1
Yolo	40	39	50	13	22	420	---	1.3	9.0
Sacramento	161	37	55	12	22	420	---	1.1	8.3
San Joaquin	77	34	33	7	29	770	---	0.7	4.8
Total or Average	1,608	46	84	15	26	622	---	2.1	10.8

PBQ&D, INC.

Many wastewater constituents have not been reported because there is insufficient reliable information available. The lack of complete information for phenols is obvious. More complete information would include a breakdown of the heavy metals (mercury, copper, lead, chromium, etc.), the inorganic metals (sodium, magnesium and calcium) and the salt radicals (chlorides, carbonates, sulfates and bicarbonates). These data would permit a determination of the sodium adsorption ratio (SAR) which is a means to classify waters with respect to the potential of sodium to cause leaf burn in sodium sensitive plants and the residual sodium carbonate (RSC) which is a measure of potential impairment of soil permeability by sodium. The lack of these data can be significant when considering the application of wastewater to land sites. Many crops have limited tolerances to salts, trace elements and other toxic materials and the wastewaters should be analyzed to determine the quantities of these specific constituents. When the specific wastewater constituents are known, the suitability of various soils and crops for wastewater application can be more precisely determined. A wastewater not meeting the required quality can be further treated or specific wastewater sources excluded from land application.

4 - Fluctuation of Wastewater Discharges

Wastewater discharges exhibit seasonal, diurnal, weekly and accidental fluctuations. Seasonal fluctuations are caused by industries and seasonal weather patterns. Principal seasonal industries are the food packing and canning industries which operate at peak activity during the later summer and fall months.

Precipitation during the November through March period will increase the flow in sanitary and combined sewers through infiltration of ground water and illegal connection of storm drains to sanitary sewers. The increased velocity during these high flows flush accumulated organic and inorganic deposits to the treatment plants. Many plants serving combined sewer systems bypass their influents directly into neighboring receiving waters during short periods of high flow.

Industrial variations depend on the process operation and maintenance activities of individual industries. In addition, accidental or intermittent discharges of very strong wastewaters containing toxic materials may occur.

Diurnal variations in wastewater flows are caused by both domestic and industrial activities. Domestic activity causes maximum sewage flows and strengths at mid-morning with a lesser peak occurring

in the early eveining. Weekly variations are also dependent upon domestic and industrial activity, generally resulting in lower loadings on weekends.

Poorly constructed or maintained sewers adjacent to the Bay are subject to increased infiltration of Bay water and fluctuations which are dependent upon the tidal cycle. This infiltration causes increased flows and increased total dissolved solids concentration in the wastewater.

The wastewater available to the land sites was assumed to be uniform in both quantity and quality throughout the year. The storage capacity available in the treatment plants and collection and conveyance systems would probably be sufficient to eliminate most normal fluctuations.

C. WASTEWATER APPLICATION AND SOIL TREATMENT

C. WASTEWATER APPLICATION AND SOIL TREATMENT

Soils and their associated vegetation have the potential to treat wastewaters to a high level of purity. High removal of many wastewater constituents can be obtained through the soil unit processes of filtration, sorption and ion exchange. However, these processes can only be maintained through careful management of wastewater application rates and the vegetative cover. The frequency and duration of soil saturation must be chosen with consideration of the soil type, vegetation desired and the constituents present in the wastewater. The interrelationships of these factors are complex. Pilot programs are required to test the suitability of soils at specific sites to treat wastewaters and to determine proper loading parameters and management concepts before large scale operations are instituted.

1 - Soil Processes

The principal physical and chemical treatment mechanisms operating in soils are filtration and sorption. They are described in the following material abstracted from Ref. 15, pp. 127-138.

"Filtration is one of the most apparent processes for which soil materials can be utilized in a water treatment system. Not only is filtration important for removing suspended particles from wastewater, but it is also the mechanism that retains microorganisms and facilitates biological treatment of dissolved and suspended organic matter. Even though the removal of suspended particles from water flowing through soils is easily observed, the processes involved are difficult to describe except in simple cases. The simple mechanisms, however, might be combined to describe more complex situations.

"Case 1 - Straining at the Soil Surface. The simplest system to describe is one having the following conditions:

a. Saturated laminar flow.
b. Rigid medium.
c. Noncohesive rigid suspended particles.
d. Suspended particles larger than the pore openings in the medium.

"Under these conditions the suspended particles accumulate on the soil surface as water passes through the soil and these particles themselves become the filter. Such a filter is capable of removing even

finer particles, by one of the several mechanisms herein described, before they reach and clog the original soil surface. This phenomenon will in fact largely be dominant if only a portion of the suspended particles are larger than the pore openings. As soon as a few such particles have accumulated, they become the straining surface for finer particles.

"While such a surface produces effective, nearly complete separation of fine suspended particles, it immediately restricts the flow, and as the accumulation of fine particles becomes thicker, its lower hydraulic conductivity dominates the system.

"Case II - Bridging. When saturated laminar flow occurs in a rigid medium receiving noncohesive rigid suspended particles slightly smaller than the pore openings, the phenomenon of bridging becomes an important factor. Under these conditions, suspended particles penetrate the soil surface until they reach a pore opening or passageway constriction that stope their passage by blocking them individually or by bridging.

"Two aspects of this mechanism are important: the relation between the largest suspended particle size and the samllest constriction along a passageway determine whether this process prevails; and accumulation of particles occurs within the porous medium behind the passageway obstruction. Because the particles accumulate within the pores of the medium rather than on the medium surface, the resistance to flow through it is greater. The resistance will be, say, two to three times as great as an equal depth of fines under the conditions of Case I. When the pores fill to the soil surface, subsequent accumulation will occur as in Case I.

"Case III - Straining and Sedimentation. This case includes all of the conditions for Cases I and II except that the suspended particles are finer than half of the smallest pore opening.

"Removal under these conditions results from flow of a portion of the fluid through the regions adjacent to grain contacts that are too small in one dimension for the passage of suspended particles, and from sedimentation of particles from the water flowing through enlarged portions of passageways.

"Characteristics of Mechanisms. The straining mechanisms of Cases I, II and III differ in the way their removal rates change as particles are removed and in the way they affect the hydraulic resistance to flow. Straining of mixed particle sizes under the conditions of Cases I and II becomes more effective as particles accumulate. Straining of mixed particles whose largest size is much smaller than the filter grain

diameter, Case III, becomes generally more effective for the smallest particles as the larger particles accumulate, but then less effective as straining sites become filled. When the straining sites are filled, suspended particles can only be removed by a mechanism other than simple straining. The available volume for accumulated fines is least for the straining conditions of Case III.

"The hydraulic conductivity, on the other hand, decreases markedly as particles accumulate under the conditions of Case I, and becomes determined by the conductivity of the layer of accumulated fines. The hydraulic conductivity under the conditions of Case II decreases even faster than in Case I as particles fill the pores of the filter. Under the conditions of Case III, however, the accumulated particles merely smooth the walls of the passageways, and the reduction in conductivity depends on the portion of cross section removed. It will in general be much less than either Case I or II.

"Unlike the straining mechanisms, removal by sedimentation, Case III, is sensitive to direction of flow and to the local velocity. Separation of common organic particles, whose density is close to that of water, is accomplished initially more rapidly by straining under ordinary flow conditions. As the straining sites fill, however, sedimentation is the only mechanism available for separating particles that are very small relative to those of the medium. The capacity of the sedimentation system for holding removed particles appears to be much larger than Case III straining, and because it can continue over long distances of filter, it can provide the greatest capacity for storage.

"<u>Cases with Cohesive Particles</u>. When suspended particles are cohesive, they can form aggregates. Clay particles, bacteria, many organic particles, and many hydrous oxides and other hydrated compounds are at least weakly cohesive under common conditions. The filtration of cohesive particles is the more usual situation.

"If the particles are aggregated before they enter the filter, the size distribution and density of the <u>aggregates</u> will determine their initial removal rates as the particles approach or enter the filter, as described for particles under Cases I, II and III. When the particles accumulate on the soil surface or clog pores by bridging, they will continue to accumulate as described for rigid particles. If, in addition, there develops a sufficient difference in pressure across the clogged zone, the aggregates will deform and be forced farther into the pores of the filter until they appear at the effluent of the filter or until there is sufficient mechanical resistance of the aggregates to deformation to resist further penetration. This situation calls for drastic corrective action and should be

avoided.

"Cohesion of suspended particles probably occurs infrequently without adhesion of suspended particles on the grains of the filter material. As pointed out above, larger suspended particles tend to gather smaller ones. The argument can be extended to the even larger particles of the filter matrix.

"It is apparent that all cases have not been covered in this summary. Particles that alter their character during their passage or lodgment in the filter are important but as yet difficult cases to describe. Biological growths, for example, are of central importance to this study, but present knowledge limits the description to (a) continuously anaerobic growths cause clogging; and (b) wetting and drying is essential to maintenance of permeable structure of a soil-mineral-organic matrix.

"Chemical reactions that continue within the filtering matrix also make filtration processes difficult to describe.

"There is little question that filtration system design will benefit from developing knowledge of the mechanisms of transport, aggregation, deformation, chemical reaction and separation processes that go on within the filter pores.

"Sorption is the second major physical/chemical mechanism. The preceding section on the mechanisms of removal of cohesive particles from fluid flowing through soil or soil materials can be extended to include removal of molecules, groups of atoms (droplets), and atoms that adhere by one mechanism or another to the surfaces of soil matrix particles. No effort will be made here to distinguish between particles held near the surface, on the surface, or in an irregular surface; the noncommital term "sorption" is used to include all of these cases.

"In its most general sense, sorption can be described as accumulation at interfaces of materials, usually in different phases, and it can include particles that migrate into the surbent (i.e., are absorbed). Sorption by soil or biological materials provides the separation of dissolved constituents from wastewaters and their retention for bio-degradation or chemical oxidation. The brief description presented here should help in the evaluation of the importance of these processes to a wastewater treatment system design."

"Affinity of dissolved or suspended matter (sorbate) for particles in the soil (sorbent) results from the attraction of an unlike electrostatic charge (ion exchange, for example), van der Waal's attraction (all matter

at close proximity), and valence bonds. A fourth factor that contributes to the affinity between sorbent and sorbate is the solubility of the sorbate in the surrounding fluid. If the molecule is hydrophobic, for example, it will try to leave a water solution and will accumulate at any surface not repulsive to it. These factors emphasize that sorption is a process that involves simultaneously the solvent, the sorbate and the sorbent.

"Most materials are readily sorbed from water solution: water molecules appear to like other water molecules better than they do most substances. This is one reason that so many compounds accumulate at soil-water and water-gas interfaces.

"One important exception to this generalization is the strong electrolytes. These are compounds that dissociate in water and exist in solution as independent charged particles, or ions. They appear to have a greater affinity for water than for other ions, they tend to hydrate and exist in clusters of water molecules if their diameter is smaller than that of the potassium ion, and they tend to have a lower concentration at water-gas interfaces than in the bulk of the solution. Their charge, however, causes their accumulation in solution near charged surface sites on clay minerals.

"Ions held near clay mineral surfaces can be displaced by other ions in solution or "exchanged." Net exchange, or alteration of the proportion of ions of different kinds, tends to occur if there is a greater abundance of one kind in the displacing solution than in a solution in equilibrium with the sorbed phase, or if the ions in the displacing solution have a smaller hydrated size, or if they have a greater charge so that the attraction between the ion and the charged mineral surface is greater.

"If a solution containing ions different from those in equilibrium with ions in the sorbed phase is passed continuously through a soil with a capacity to sorb ions, an Ion Exchange Capacity (IEC), there will be a progressive exchange in the direction of flow between those in solution and those already sorbed. There will be a transition region where active alteration of the sorbed phase is occurring, followed by the region where the sorbed phase has already reached equilibrium with the ions in the displacing solution. Present knowledge is inadequate to predict such exchange rates and the interstitial solution composition except in very simple systems.

"Two aspects of ion exchange are important to wastewater treatment: The exchange process does not reduce the ion concentration of the water on an equivalents per liter basis because already sorbed ions are displaced by the newly sorbed ions. The net effect of ion exchange on the composition of waters flowing through soils is to delay the move-

ment of the sorbed ions. If there is a temporal alteration, such as radioactive decay, utilization by plants, or chemical reaction, such a delay would be beneficial. Otherwise, the major effect of exchange processes is that already described on soil structure and permeability. Eventually the sorbed ions will reach equilibrium with the entering solution along the entire path of flow. If this occurs within the life of a wastewater treatment system, the effluent constituent ions will be the same as those of the influent.

"When water flows through soil, equilibrium concentrations are seldom attained in the region of the "front" of intruding solute. The kinetics of such a system can be limited by diffusion to the surface of the sorbent particle (small particles move faster, the flux is proportional to concentration gradient), by intraparticle diffusion, or by the nature of flow in the porous matrix. The discussion of equilibrium sorption here does show that the factor important to sorption capacity is surface area, or number of sorbing sites, and that the relation between concentration of dissolved and sorbed phases depends on the bond strengths with which the sorbed molecules or ions are held or on the tendency for the solvent to reject the sorbate, and on the number of unoccupied sites available for sorption.

"Sorption is a complex, vital process in wastewater treatment systems that deserves further study. Sorption phenomena can be seen to be essential parts of filtration, ion exchange, interface accumulations and precipitation (self-adsorption). It appears that quantitative determinations of the effects of these processes, if desired, will usually have to be made on a sample of the particular system itself, or on analogous systems. Useful information for design purposes can be obtained by observing the behavior of typical wastes on the simplest porous media as done with settled domestic sewage by Orlob and Krone." (Ref. 15)

2 - Soil Classification

Natural soils may be considered as complex mixed-media filters having particle sizes ranging from over 500 microns (0.5 millimeter) to less than one micron. Their properties will vary widely and this variation is indicated by a variety of generalized descriptive terms. Table II-C-1 gives a few of the methods and terms used to classify soils.

No single classification is sufficient to establish the hydraulic percolation capacity (infiltration), water holding capacity (field capacity) and structural strength of a particular soil. The capacities of a soil to support vegetation and to modify the constituents of applied wastewater

Table II-C-1

SOIL AND SUB-SOIL CLASSIFICATION METHODS

Parameter	Descriptive Terms
Texture (very general)	Light, medium, heavy, etc.
Particle Size Distribution	Sandy loam, silty clay, etc.
Association (identifies characteristic by location)	Yolo-Brentwood, Marvin-Rincon, etc.
Surface Runoff Potential 1/	Group A, B, C, etc.
Capability (for stated 1/ use such as agriculture)	Class I, II, III, etc.
Geologic Location	Marine Terrace, Alluvial Fan, etc.

NOTES:

1/ From Ref. 29

can be estimated with some degree of risk by interpretation of classifications and by judgement.

A basic aspect of most soil classifications in the United States is the use of descriptive local names such as Yolo, Rincon and Panoche which generally refer to towns, counties or other identifiable areas. Hence, a Yolo soil is common in but not restricted to, Yolo County, California. This same or similar soil located in another county may, however, be given another name such as Columbia. From these names, coupled with a broad knowledge of local conditions, a classification of soil suitability for an identified purpose can be made.

Table II-C-2 gives a description of each of the soil associations occurring in the nine selected sites and an estimate of its infiltration capacity without regard to the vegetative cover that may be assigned. The basis for this estimate is discussed in part 3 of this section. The soils listed in Table II-C-2 are further discussed in Section E.

There are presently no reliable parameters or probability distributions that describe the actual field variation in areal extent and characteristics of any particular soil association. Following sections in this report utilize general classifications and characteristics of soil associations and do not demonstrate the variations that occur among soils and within soil associations. The general classifications and characteristics utilized are approximations and must be verified by detailed field tests before assumptions of soil suitability and performance are made and before permanent facilities are constructed.

Even though soil classification by generalized soil groupings, associations or capability classes admits the possibility of substantial error, they have been widely used in the past as a basis for planning estimates. The Bureau of Reclamation uses generalized soil classes in planning irrigation projects.

3 - Soil - Water - Infiltration Relationships

The primary result of the application of wastewaters to soil is a decrease in the permeability of the soil. Figure II-C-1 represents the typical time - infiltration rate curve for applications of sterile water, clear water and wastewater to soil.

For clear water, the first portion of the curve (Stage 1) indicates a decrease in infiltration rate due to slaking of the soil. The soil slaking is caused by the affinity of the internal soil surface for water and the overcoming of the cohesive forces holding the soil system together. The increase in infiltration rate in Stage 2 is caused by the removal of air entrapped in soil by solution into the water. The final portion of the curve for clear water (Stage 3) indicates a gradual decrease in permeability from microbial action in the soil. The lack of air in the soil-water system allows anaerobic organisms to feed on the organic matter in the

Table II-C-2

SOIL ASSOCIATION PARAMETERS

Soil Association	General Position 1/	Soil Descriptions: Surface Layer 2/	Soil Descriptions: Subsoil 3/	Erosion Hazard	Effective Depth (Inches) 4/	AWC (Inches) 5/	Estimated Soil Application Limitation (ft/yr) 7/
		CAPABILITY CLASS I 6/					
Brentwood-Yolo	AF,FP	Silty clay loam	Silty clay loam	none	60+	8-11	90
Brentwood-Yolo-Sycamore	AF	Massive, blocky clay loam	Massive silty loam	none	60+	8-11	90
Columbia-Sycamore	AF	Massive sandy & silty loam	Massive fine sandy & silty loam	none	60+	6-10	90
Sorrento	AF	Granular silty clay loam	Blocky silty clay loam	none	60	>7.5	45
Lost Hills	AF	Granular clay loam	Blocky clay loam	slight	36-60+	5-10	25
Panoche	AF	Granular loam	Blocky loam	slight	60+	7.5-10	45
San Emigdio	AF	Granular sandy loam	Massive sandy loam	slight	60+	7.5-9	90
Yolo (Overflow)-Zamora	AF,FP	Massive, blocky loam & silty clay loam	Massive fine sandy laom	slight	60+	8-11	90
Chualar	AF	Blocky sandy loam	Blocky clay loam	slight	60+	8-10	90
Salinas-Mocho	AF	Blocky clay loam & silty clay loam	Massive & blocky silty clay loam	none to slight	60+	8-11	45
Brentwood-Zamora-Sorrento-Los Robles	AF,VT	Granular or blocky clay loam	Heavy blocky or light silty clay loam	none	60+	10-12	45
Cropley-Rincon	VF,AF	Blocky clay loam	Blocky clay	none	60+	8-10	45
		CAPABILITY CLASS II 6/					
Marvin-Rincon-(Tehama)	AF	Silty loam & silty clay loam	Dense clay loam or silty clay	none to slight	*	*	45
Capay-Clear Lake	BR	Silty clay	Silty clay	none	*	*	40
Capay-Clear Lake-Sacramento	BR,AF	Silty loam & silty clay loam	Clay	none to slight	*	*	30
Harrington	AF	Massive silty clay loam	Blocky clay	slight	60+	8-10	45
Columbia-Lang	AF	Massive fine sandy loam	Massive or mottled sandy loam	none to slight	60	3-9	90
Valdez-Merritt	AF	Massive or granular silty clay loam	Mottled silty clay loam	none	36-60	6-10	45
Lost Hills	AF	Granular clay loam	Blocky clay	slight	60	5-7.5	25
Pleasanton-Esparto	AF	Massive gravelly sandy loam	Massive & blocky sandy clay loam	slight	60	5-7.5	90
Merced-Temple	B	Blocky or granular silty clay	Blocky or silty clay	slight	36-60	6-9	25
Pajaro	AF	Fine sandy laom	Massive clay	slight	30-50	5-6.5	20
Clear Lake	B,FP	Massive clay	Massive clay	none to slight	52-60	8.75-10	15
Pleasanton-Zamora	AF,FP	Massive gravelly loam or silty clay loam	Massive gravelly clay or silty clay loam	slight	60+	9-11	45
Yolo-Cortina-Pleasanton	AF	Massive gravelly sandy loam	Massive loam or gravelly sand	slight	60+	3-10	90
Farrallone	AF	Gravelly sandy loam	Blocky sandy loam	slight	60+	5-7.5	90
Cropley	AF	Weak granular clay	Silty clay	none	60+	10-12	45
Clear Lake-Pacheco	B,AF	Blocky clay or clay loam	Massive clay or loam	none to slight	36-60+	6-11	45
Tunitas-Lockwood	VT	Blocky loam or granular clay loam	Clay or massive shaly clay loam	none to slight	60+	10+	30
Valdez-Columbia	AF	Silty or sandy loam	Mottled sandy loam	*	*	*	90
		CAPABILITY CLASS III 6/					
Valdez	FP	Mottled silty clay loam	Mottled silt	none	60+	4-6	45
Arbuckle-Cortina	AF	Massive gravelly or sandy loam	Massive gravelly clay or sandy loam	slight	10-36	1-6	45
Sacramento-Willows	BR	Blocky clay	Mottled clay	none	60+	8-10	15
Columbia-Sandy Alluvial	AF,FP	Massive or single-grain sandy loam	Mottled sandy loam and coarse sand	removal and deposition	60+	4+	90
Stockton-Sacramento	B,BR	Blocky, mottled clay	Massive, mottled clay	slight	30-60+	5-10+	15
Sycamore-Colusa	AF,BR	Silty clay loam	Massive, mottled silty clay loam	slight	60+	5-10+	45
Landlow-Marvin	BR	Blocky silty clay loam	Blocky clay	slight	40-60+	8-10+	45
Oxalis	B	Hard blocky clay	Hard blocky silty clay	slight	20-36	3-5	15
Merced-Temple	B	Blocky or silty clay	Blocky clay or silty clay	slight	30-60+	6-9	25
Cotati	UT	Massive fine sandy loam	Coarse clay	mod.	24-36	4.2-5.8	30
Huichica-Wright	VT,FP	Massive loam	Coarse mottled clay	slight	20-36	3-10	30
Antioch-Gloria	ST	Massive blocky loam	Clay	high	8-24	2-6	15
Chualar	AF,VT	Granular or blocky sandy loam	Blocky clay loam	slight	60+	8-10	90

			clay loam				
Landlow-Marvin	BR	Blocky silty clay loam	Blocky clay	slight	40-60+	8-10+	45
Oxalis	B	Hard blocky clay	Hard blocky silty clay	slight	20-36	3-5	15
Merced-Temple	B	Blocky or silty clay	Blocky clay or silty clay	slight	30-60+	6-9	25
Cotati	UT	Massive fine sandy loam	Coarse clay	mod.	24-36	4.2-5.8	30
Huichica-Wright	VT, FP	Massive loam	Coarse mottled clay	slight	20-36	3-10	30
Antioch-Gloria	ST	Massive blocky loam	Clay	high	8-24	2-6	15
Chualar	AF, VT	Granular or blocky sandy loam	Blocky clay loam	slight	60+	8-10	90
Placentia	UT	Massive sandy loam	Clay	slight	18-30	2-4	15
Elkhorn	MT	Blocky sandy loam	Massive sandy clay loam	slight to mod.	40-60	6.5-7.5	45
Watsonville-Elkhorn	VT	Granular loam or sandy loam	Blocky clay or sandy clay loam	mod.	25-30	2-4	45
Sacramento	B	Clay	Mottled blocky clay	none	to water table	5-10	20
Staten-Egbert	FP	Mucky clay loam	Clay loam & fibrous peaty material	mod.	to water table	3-7	15
Perkins-Kimball	VT	Massive clay loam	Blocky clay	mod.	20-60	4-9	15
Ryde-Egbert	AF	Silty clay loam	Mottled mucky clay loam	mod. to high (wind)	60+	7.5+	15
Staten-Venice	FP	Muck	Peaty muck	high (wind)	60+	7.5+	15
Dinuba	AF	Sandy loam	Mottled sandy loam	none	32-48	4-6	30
Stockton-Landlow	B, BR	Clay	Clay	None	30-54	5-7	15
		CAPABILITY CLASS IV 6/					
Corning-Hillgate	UT	Gravelly loam	Gravelly clay	mod.	*	*	20
Pescadero-Willows	BR	Mottled & silty clay	Mottled & silty clay	none	*	*	15
Sehorn-Balcolm	B	Clay	Clay	slight	*	*	10
Ayar-Rumsey	RU	Granular clay	Blocky clay	mod.	20-36	3-6	5
Sycamore-Tyndall	FP	Silty clay loam & sandy loam	Silty clay loam & sandy loam	none	*	*	45
San Joaquin-Alamo	UT	Massive loam & coarse blocky clay	Blocky mottled clay	none to slight	12-36	2-6	10
Los Banos	VF	Blocky clay loam	Clay	slight to mod.	60	>5.7	5
Positas	AF	Massive gravelly fine sandy loam	Gravelly clay	slight	20-36	3-5	5
Lethent	AF	Blocky cilty clay loam	Blocky silty clay	none	60	5-7.5	15
Goldridge	MT	Massive fine sandy loam	Massive sandy clay	mod.	41-57	5-7.5	20
Rohnerville-Kneeland	MT, SU	Granular loam	Massive sandy clay or fine clay loam	slight	18-40	3.5-6.5	10
Reyes	TF	Fine granular silty clay	Coarse silty clay	slight	31-51	5.6-6.2	10
Metz-Riverwash	FP	Loose silts & sands	Loose stratified sands	high	variable to 60+	1-5	45
Tierra-Colma	ST	Granular sandy loam	Blocky loam & clay loam	mod.	30-60+	2-4	10
Altamont-San Benito-Linne	RU	Clay or silty clay loam	Blocky clay & silty clay loam	mod.	20-60	4-8	15
Solano-San Ysidro	VT, BR	Massive loam	Silty or blocky clay	slight to mod.	10-24	<4	10
Linne-Altamont	RU	Clay & granular clay loam	Mottled clay & blocky clay loam	mod.	20-60	4-8	15
Diablo-Altamont	RU	Clay	Blocky clay	mod.	36-60	5-8	5
Pescadero	BR	Clay	Blocky clay	slight	20-36	5-7	5
		CAPABILITY CLASS V 6/ CAPABILITY CLASS VI 6/					
Reyes-Tamba	TF	Mottled clay & muck	Mottled clay & muck	none	20-36	4-6	5
Suisun-Joice	TF	Peaty muck & clay	Peaty muck & clay	none	varies with water table	6-10	5
Dibble-Millsholm	SU	Clay loam & rocky loam	Clay & stony loam	mod. to high	*	*	5
Altamont-Rumsey	RU	Granular clay loam	Blocky hard clay	mod.	20-36	3-6	5
Alluvial Land-Riverwash	AF	Poorly mixed sand and alluvium ranging from sandy loam		*	*	*	90
Goldridge	MT, ST	Massive fine sandy loam	Hard massive sandy clay	mod.	41-57	5-7.5	30
Hugo-Laughlin-Josephine	SU	Gravelly loam	Massive loam, clay loam	slight to mod.	10-48	1.75-8	5
Steinbeck-Los Osos	MT, SU	Massive loam & clay loam	Hard coarse & massive clay	slight to mod.	24-55	6-8	5
Hugo-Josephine	RU, SU	Gravelly loam	Blocky loam & clay loam	slight to mod.	24-48	4.5-8	5
Los Osos	SU	Hard massive clay loam	Hard massive clay	mod.	20-28	4-6	5
Laughlin-Parrish	RU, SU	Grannular, blocky loam	Massive loam & clay loam	mod.	10-36	2-7.5	5
Goulding-Toomes	SU	Granular clay loam & hard rocky loam	Hard massive clay loam	slight to mod.	8-24	1-4.5	5
Antioch-Gloria	ST	Hard blocky loam	Very hard clay	high	8-24	2-6	5
McCoy	SU	Blocky hard clay loam	Blocky hard clay loam	mod.	36-48	5-8	5
Los Gatos-Cotati	SU	Hard granular clay loam	Blocky hard clay loam	high	20-60	4-8	5
Gloria-Placentia	ST	Hard massive loam & sandy loam	Very hard clay	high	8-30	1-4	5
Lobitos-Gazos	SU	Granular loam	Hard clay loam & granular silty loam	high	25-30	4-6	5
Tierra-Colma	ST	Granular sandy loam	Hard clay loam	high	30-60+	2-4	5
Arnold	RU	Loamy sand	Loamy sand	high	20-36	>4	30
Altamont-San Benito	**SU**	**Clay & silty clay loam**	**Blocky clay & silty clay**	**mod.**	**20-60**	**4-8**	**10**

(2)

[illegible]	SU	Hard massive clay loam	Hard massive clay	mod.	20-28	4-6	5
Laughlin-Parrish	RU,SU	Granular, blocky loam	Massive loam & clay loam	mod.	10-36	2-7.5	5
Goulding-Toomes	SU	Granular clay loam & hard rocky loam	Hard massive clay loam	slight to mod.	8-24	1-4.5	5
Antioch-Gloria	ST	Hard blocky loam	Very hard clay	high	8-24	2-6	5
McCoy	SU	Blocky hard clay loam	Blocky hard clay loam	mod.	36-48	5-8	5
Los Gatos-Cotati	SU	Hard granular clay loam	Blocky hard clay loam	high	20-60	4-8	5
Gloria-Placentia	ST	Hard massive loam & sandy loam	Very hard clay	high	8-30	1-4	5
Lobitos-Gazos	SU	Granular loam	Hard clay loam & granular silty loam	high	25-30	4-6	5
Tierra-Colma	ST	Granular sandy loam	Hard clay loam	high	30-60+	2-4	5
Arnold	RU	Loamy sand	Loamy sand	high	20-36	>4	30
Altamont-San Benito	SU	Clay & silty clay loam	Blocky clay & silty clay loam	mod.	20-60	4-8	10
		CAPABILITY CLASS VII 6/					
Positas	ST	Gravelly loam	Gravelly clay	very high	10-20	1-3	5
Dibble-Millsholm	SU	Clay & rocky loam	Clay & stony loam	mod. to high	*	*	5
Cibo	SU	Hard stony clay	Hard blocky clay	*	*	*	5
Kettleman	RU	Granular silty clay loam	Blockly silty clay loam	mod. to severe	10-48	2-5	5
Vallecitos	SU	Granular stony clay loam	Hard massive clay loam	mod.	15-25	3-5	5
Los Banos	ST	Hard massive clay loam	Hard blocky clay	mod. to high	20-30	2-3.5	5
Yorkville-Sutherlin	RU	Hard clay loam	Hard mottled & gravelly clay	mod. to high	20-45	5-6	10
Henneke	SU	Gravelly loam	Cobbly loam	*	*	*	10
Los Gatos-Maymen (Henneke)	RU,SU	Granular loam & massive sandy loam	Massive gravelly clay loam	mod. to high	10-40	1.5-6.5	10
Loamy Alluvial Land	AF	Sands, loams & coarse loams	Stratified gravel, sands & loams	variable	60+	4-10	90
Jiggs-Kidd-Rock	SU	Gravelly & rocky sandy loams	Gravelly loam & sandy clay loam	slight	0-25	.05-5	20
Spreckels-Felta	SU	Blocky & gravelly loam	Hard massive clay & gravelly clay loam	slight to mod.	14-26	3-5.5	20
Sheridan	SU,M	Gravelly loam	Gravelly sandy loam	mod.	30-48	5-6	20
Sheridan	SU,M	Coarse sandy loam	Coarse sandy loam	high	15-30	3-5	20
Arnold	SU	Blocky loamy sand	Massive loamy sand	mod.	30-60	2-4	20
Vista	M	Granular sandy loam	Massive sandy loam	high	20-24	3-4	20
Hugo-Butano-Josephine	SU,M	Granular silty loam	Hard blocky sandy loam & clay loam	high	30-40	3-6	20
Arnold-San Andreas	SU	Sand & sandy loam	Sandy loam & loamy sand	high	36-60+	3-7	20
Lobitos-Gazos-Santa Lucia	SU,M	Granular shaly loam & silty loam	Hard granular loam & silty loam	mod. to high	25-30	4-6	5
Sweeney-Mindego	M,SU	Hard granular clay loam	Hard blocky clay & clay loam	high	30-40	4-6	5
Los Gatos-Gaviota-Sobrante	SU	Blocky sandy loam & granular clay loam	Massive loam, sandy loam & clay loam	high to very high	20-36	3-7	5
Los Osos-Millsholm-Gazos	SU	Blocky clay loam & silty loam	Clay, loam & blocky clay loam	high to very high	10-36	4-7	5
Los Gatos-Gaviota	SU	Blocky & sandy loam	Massive loam & sandy loam	high to very high	20-36	3-6	20
		CAPABILITY CLASS VIII 6/					
Rockland	SU	Loose stones & boulders lying on the surface and embedded in shallow soil material		very high	*	*	5
Rough Rockland	M	Coast range areas with slopes greater than 50% or more than 50% rock outcrops		*	*	*	5
Dune Land	MT	Stratified coarse loamy sand & fine sand		high (wind)	60+	2-3	30
Tidal Flats	TF	Mixed plant remains. Bay mud and sediments		slight	20-36	4-6	10
Cieneba-Sheridan	M	Gravelly sandy loam	Gravelly sandy loam & weathered granite	very high	5-36	1-4	5
Maymen-Los Gatos	SU,M	Granular gravelly loam	Granular loam & gravelly clay loam	high	12-24	>3	5
Santa Lucia-Rockland	SU,M	Shaly loam & rock outcrop	Shaly clay loam & rock outcrop	high	10-24	1-3	5

NOTES:

1/

	Estimated Range of Slope for Proposed Use (%)
FP - Flood Plain	0-2
TF - Tidal Flats	0-2
AF - Alluvial Fan	0-2
VF - Valley Floor	0-5
B - Basin	0-5
BR - Basin Rim	0-10
MT - Marine Terrace	10-30
VT - Valley Terrace	0-10
UT - Undulating Terrace	10-20
ST - Steep Terrace	10-30

2/ Typically about 5 to 8 inches in thickness (the ordinary plowed layer).

3/ The part of the profile below the surface layer.

4/ The depth to which a soil is readily penetrated by roots and utilized for extraction of water and plant nutrients.

5/ (Available water holding capacity); the portion of water within the effective depth of a soil that can be readily absorbed by plant roots.

(3)

			Massive loamy sand	mod.	30-60	2-4	20
	M	Granular sandy loam	Massive sandy loam	high	20-24	3-4	20
Hugo-Butano-Josephine	SU, M	Granular silty loam	Hard blocky sandy loam & clay loam	high	30-40	3-6	20
Arnold-San Andreas	SU	Sand & sandy loam	Sandy loam & loamy sand	high	36-60+	3-7	20
Lobitos-Gazos-Santa Lucia	SU, M	Granular shaly loam & silty loam	Hard granular loam & silty loam	mod. to high	25-30	4-6	5
Sweeney-Mindego	M, SU	Hard granular clay loam	Hard blocky clay & clay loam	high	30-40	4-6	5
Los Gatos-Gaviota-Sobrante	SU	Blocky sandy loam & granular clay loam	Massive loam, sandy loam & clay loam	high to very high	20-36	3-7	5
Los Osos-Millsholm-Gazos	SU	Blocky clay loam & silty loam	Clay, loam & blocky clay loam	high to very high	10-36	4-7	5
Los Gatos-Gaviota	SU	Blocky & sandy loam	Massive loam & sandy loam	high to very high	20-36	3-6	20
		CAPABILITY CLASS VIII 6/					
Rockland	SU	Loose stones & boulders lying on the surface and embedded in shallow soil material		very high	*	*	5
Rough Rockland	M	Coast range areas with slopes greater than 50% or more than 50% rock outcrops		*	*	*	5
Dune Land	MT	Stratified coarse loamy sand & fine sand		high (wind)	60+	2-3	30
Tidal Flats	TF	Mixed plant remains. Bay mud and sediments		slight	20-36	4-6	10
Cieneba-Sheridan	M	Gravelly sandy loam	Gravelly sandy loam & weathered granite	very high	5-36	1-4	5
Maymen-Los Gatos	SU, M	Granular gravelly loam	Granular loam & gravelly clay loam	high	12-24	>3	5
Santa Lucia-Rockland	SU, M	Shaly loam & rock outcrop	Shaly clay loam & rock outcrop	high	10-24	1-3	5

NOTES:

1/

	Estimated Range of Slope for Proposed Use (%)
FP - Flood Plain	0-2
TF - Tidal Flats	0-2
AF - Alluvial Fan	0-2
VF - Valley Floor	0-5
B - Basin	0-5
BR - Basin Rim	0-10
MT - Marine Terrace	10-30
VT - Valley Terrace	0-10
UT - Undulating Terrace	10-20
ST - Steep Terrace	10-30
RU - Rolling Upland	10-30
SU - Steep Upland	20-30
M - Mountains	>30

2/ Typically about 5 to 8 inches in thickness (the ordinary plowed layer).

3/ The part of the profile below the surface layer.

4/ The depth to which a soil is readily penetrated by roots and utilized for extraction of water and plant nutrients.

5/ (Available water holding capacity); the portion of water within the effective depth of a soil that can be readily absorbed by plant roots.

6/ CAPABILITY CLASSES (Ref. 29)

I: Very deep, well drained, medium to moderately fine textured, nearly level soils. These soils typically occupy valley bottoms and fans and are generally suitable as rapid infiltration areas.

II: Deep to very deep, moderately to well drained, moderately coarse to fine textured, nearly level soils. These soils typically occupy alluvial fans, flood plains and basins, and are generally suitable as rapid infiltration and cropped areas.

III: Moderately deep to very deep, poorly to well drained, fine to very coarse textured, nearly level to strongly sloping soils. These soils typically occupy flood plains, basins, and dissected terraces and are generally suitable as cropped and pasture areas.

IV: Shallow to very deep, poorly to well drained, loam and clay loam textured with some claypan subsoils, nearly level (flood basins) to moderately steeply sloping soils. These soils typically occur in basins (some outside present levee systems) and on terraces, and may be suitable as cropped areas but are generally utilized for pastures.

V: Not included in County Reports.

VI: Moderately deep, well drained, medium to fine textured, steeply sloping soils. These soils occur on steep terraces and uplands and may be suitable as pasture areas but are generally utilized for forests.

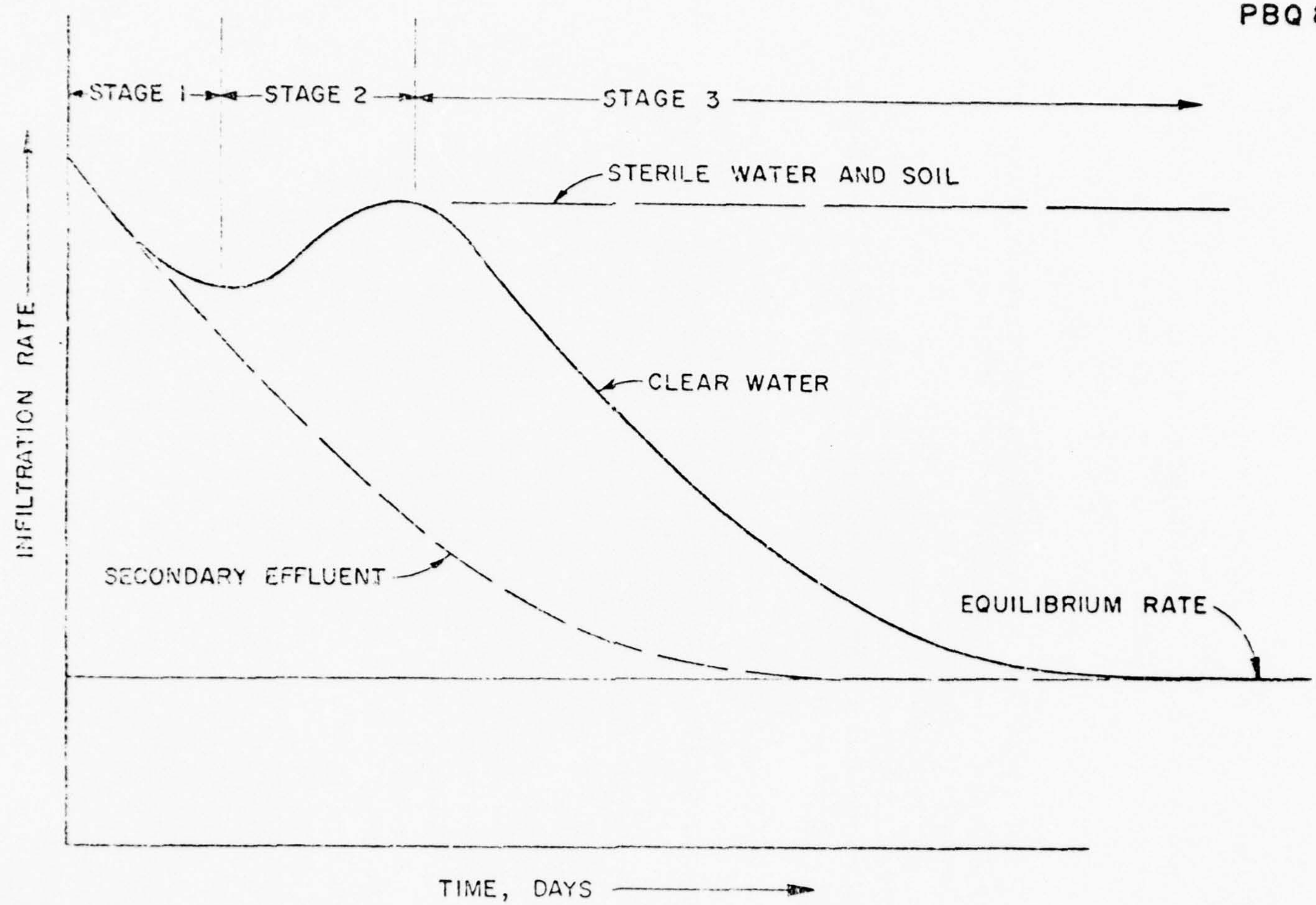
VII: Shallow to moderately deep, well drained and moderately eroded, gravelly to rocky textured with claypan, shale and sandstone substrate, steeply to very steeply sloping soils. These soils occur on steep to very steep uplands and are generally suitable for forests.

VIII: Very shallow, very coarse and eroded soils with frequent rock outcrops. These soils occupy steep rocky uplands, gullies, and stream channels, and are generally excluded.

7/ Estimated from the maximum application rates given in Figure II-C-4 and a four-day rotation schedule consisting of one day of loading and three days of soil resting.

* No data available.

(3)



SOIL INFILTRATION RATE RESPONSES

Figure II-C-1

(From Ref.17)

soil-water system and produce biological slimes.

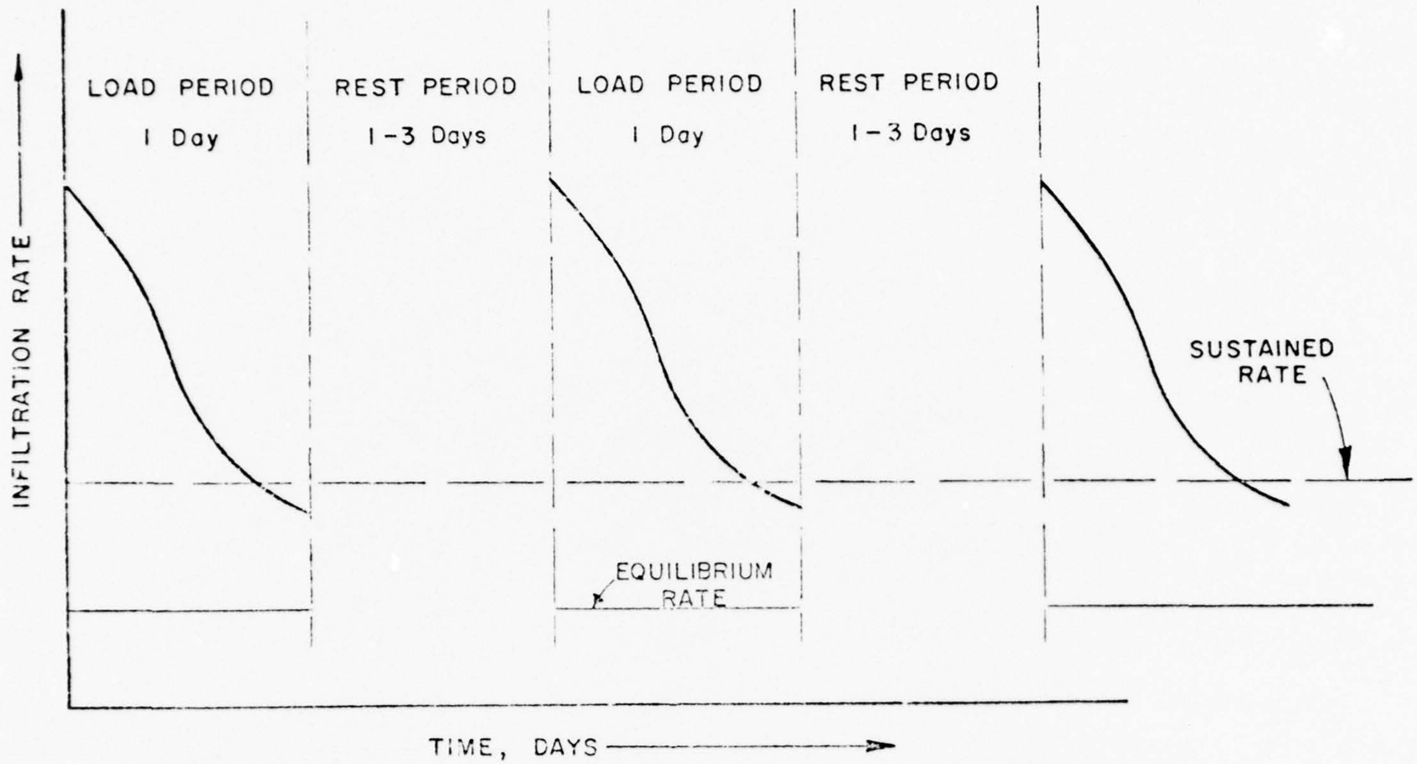
When sterile water is applied to sterile soil, the long-term decrease in infiltration rate due to microbial action does not occur. This fact gives an indication that the decrease in permeability from wastewater application is caused by anaerobic slimes in the soil-water system. The treatment plant effluent with its large supply or organic nutrients causes a rapid growth of microorganisms and a continuous decrease in the infiltration rate.

Figure II-C-2 shows that a water-soil system should be intermittently rested to restore the infiltration capacity of the soil. In resting, air becomes available to the microorganisms and the organic material is decomposed by aerobic organisms thus, "reopening" the clogged soil pores and restoring the infiltrative capacity of the soil system. The sustained rate is the estimated average long-term rate resulting from the combination of application and resting periods.

In almost all soils a resting period dries out the soil and restores aerobic conditions and the initial infiltration capability. Resting periods appropriate to any locale must be established by testing under field conditions. Generally, reports on wastewater application systems indicate that for about one half to three-fourths of the time no wastewater should be applied.

Extensive tests on disturbed samples of five sandy soils in California were conducted at Lodi, California in 1953. Physical and chemical characteristics of these soils are shown in Table II-C-3. Lysimeters filled with these soils were used to determine infiltration rates for fresh water and <u>primary</u> sewage effluents. Those infiltration rates achieved for fresh water might be considered representative of the infiltration rates related to the structure of each of the soils.

The University of California at Davis has carried out studies of the infiltration capacities of 20 covered test plots of about 450 square feet each located in a 100 acre test site at their West Side Field Station near Firebaugh, California. The tests were conducted by ponding fresh water on each test plot until the infiltration rate was stabilized. The water was then removed from the plot and the changes in soil moisture content at various depths were measured continuously until near-equilibrium conditions were achieved. The stabilized infiltration rates (IR) and the drainage rates for selected plots are shown in Figure II-C-3. Although the entire test site is classified as a Panoche Series soil the infiltration rates varied by a factor of nearly 100. Similar variations can be expected in most soil associations.



LONG-TERM SOIL INFILTRATION CAPACITY

Figure II-C-2
(Based on Ref. 17)

Table II-C-3

OBSERVED INFILTRATION RATES FOR FIVE PERVIOUS CALIFORNIA SOILS 1/

Soil Characteristic	Oakley	Yolo	Hanford	Hesperia	Columbia
	Physical and Chemical Characteristics				
Description	Sand	Sandy Loam	Fine Sandy	Sandy Loam	Sandy Loam
Parent Material	sandy mixed alluvium wind modified	sedimentary alluvium	granitic alluvium	granitic alluvium	mixed alluvium
Soil Reaction	slightly acid	neutral	neutral	neutral	neutral
Sub-surface drainage	excessive	good	good	good	good
Particle Size - percent					
clay 0.002mm	5	3	6	8	10
silt 0.002 - 0.05 mm	9	19	21	30	24
very fine sand 0.05-0.1mm	15	20	16	12.5	18
fine sand 0.1 - 0.2 mm	26	33	25	17.5	29.5
medium sand 0.2-0.5 mm	42	24.5	29	27.5	11
coarse sand 0.5 mm	3	0.5	3	4.5	7.5
Modal size - mm	0.205	0.170	0.210	0.180	0.180
Effective size - mm 2/	0.020	0.021	0.0074	0.002	0.0033
Uniformity coeff. 3/	11.2	8.1	24.9	67.3	47.3
Monovalent cations - mc/100g	0.24	0.43	0.72	0.89	0.51
Divalent cations - mc/100g	2.79	13.98	5.66	8.02	5.67
Exchange capacity - mc/100g	3.03	14.41	6.38	8.91	6.18
	Observed Infiltration of Water Into Soils (ft/day)				
Initial (fresh water)	29	10	6.4	5.2	1.75
After 15 days	47	13	2.3	1.85	0.40
After 30 days	43	10.5	1.4	1.15	0.30
After 45 days	34	9	0.85	---	0.50
After 60 days	26	7.5	0.60	---	0.74
After removal of entrapped air from soil	47 @t=15	20 @t=4	4.25 @t=6	4.5 @t=5	0.70 @t=50
Total water introduced into soil during first month-feet depth	1213	380	75.9	71.0	17.0
After 10 weeks with primary effluent	0.08	0.25	0.2	0.2	0.2

NOTES:

1/ From "An Investigation of Sewage Spreading on Five California Soils"

2/ 10 per cent less than size in mm

3/ $U.\ C. = \frac{60 \text{ per cent less than size - mm}}{10 \text{ per cent less than size - mm}}$

coarse sand 0.5 mm	3	0.5	3	4.5	7.5
Modal size - mm	0.205	0.170	0.210	0.180	0.180
Effective size - mm 2/	0.020	0.021	0.0074	0.002	0.0033
Uniformity coeff. 3/	11.2	8.1	24.9	67.3	47.3
Monovalent cations - mc/100g	0.24	0.43	0.72	0.89	0.51
Divalent cations - mc/100g	2.79	13.98	5.66	8.02	5.67
Exchange capacity - mc/100g	3.03	14.41	6.38	8.91	6.18
	Observed Infiltration of Water Into Soils (ft/day)				
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After 15 days	47	13	2.3	1.85	0.40
After 30 days	43	10.5	1.4	1.15	0.30
After 45 days	34	9	0.85	---	0.50
After 60 days	26	7.5	0.60	---	0.74
After removal of entrapped air from soil	47 @t=15	20 @t=4	4.25 @t=6	4.5 @t=5	0.70 @t=50
Total water introduced into soil during first month-feet depth	1213	386	75.9	71.0	17.0
After 10 weeks with primary effluent	0.08	0.25	0.2	0.2	0.2

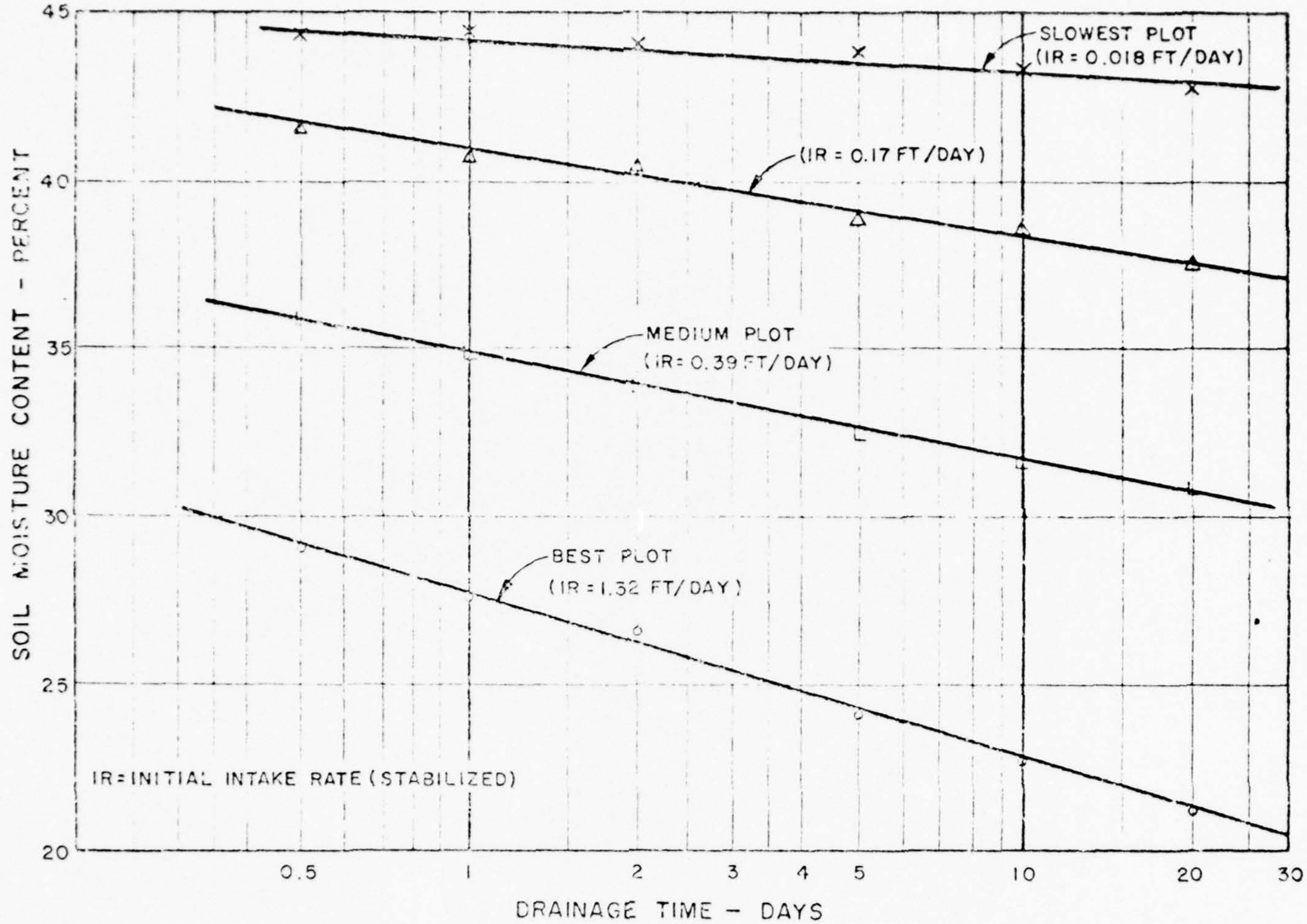
NOTES:

1/ From "An Investigation of Sewage Spreading on Five California Soils"

2/ 10 per cent less than size in mm

3/ $U. C. = \frac{60 \text{ per cent less than size - mm}}{10 \text{ per cent less than size - mm}}$

PBQ & D, Inc.



VARIATION OF SOIL INTAKE AND INTERNAL
DRAINAGE RATES FOR PANOCHE SERIES SOIL

Figure II-C-3

(From unpublished data from University of California, Davis
Details of experiment are given in report text.)

In contrast to the infiltration rates for fresh water, Table II-C-3 shows equilibrium infiltration rates for primary effluent on the order of 0.2 feet per day. In a short time frame these lower rates are generally attributed to an organic clogging mat produced by sewage under anaerobic conditions. Essentially, the mat is a slime of microflora and microfauna which grows rapidly when nutrients in treated sewage effluent are available. For soils with particles less than some critical size, this mat is relatively independent of the character of the supporting medium and does not vary widely from situation to situation (Ref. 14, p. 94).

It must be emphasized that the very broad ranges of values used to describe various types of soil and the great variety of soils and infiltration rates which may occur in an application area make it imperative that extensive and detailed sampling and analysis be carried out before any site is actually designed or used for wastewater application.

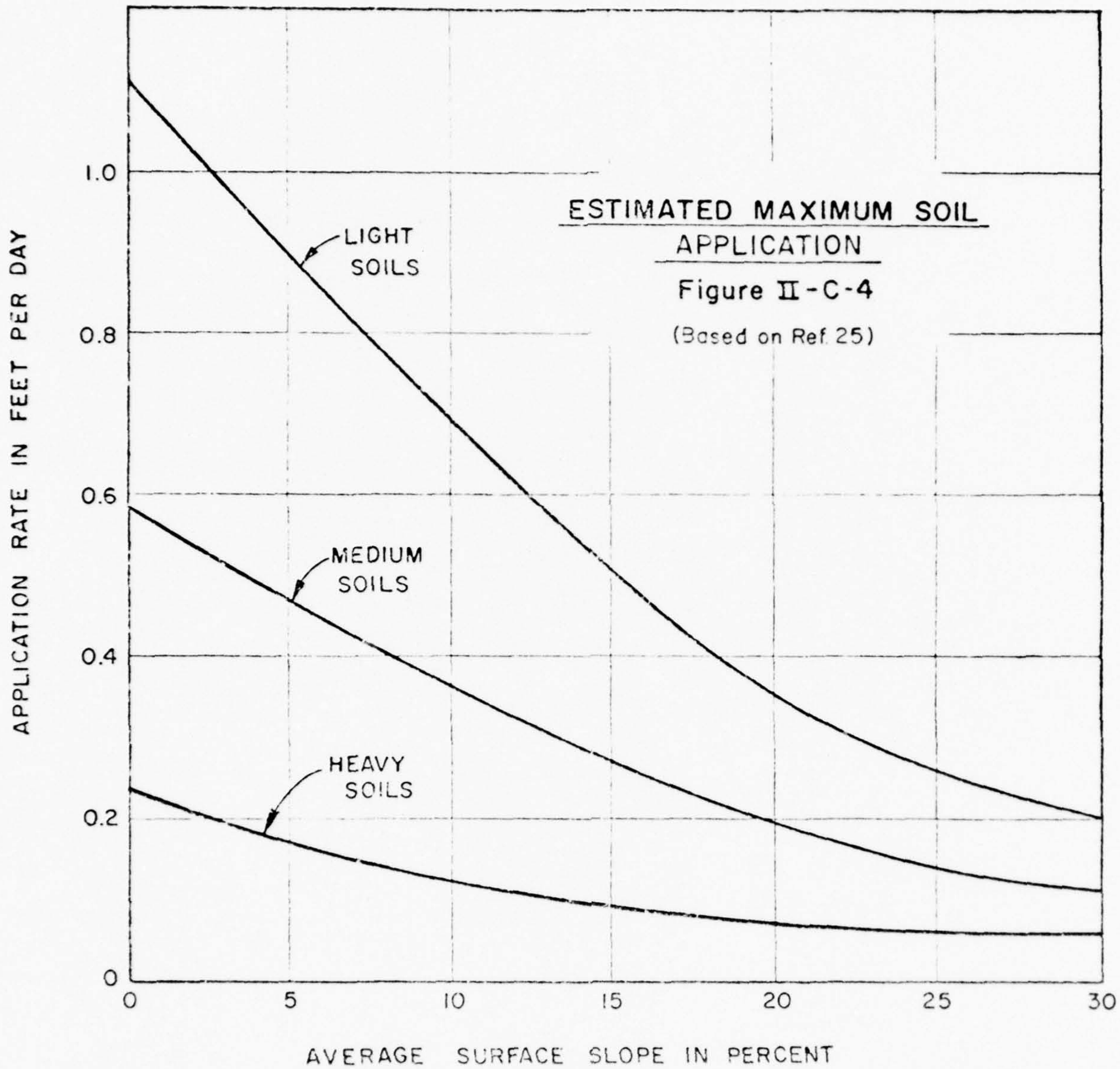
Figure II-C-4 shows a general relationship between application rate, soil texture and surface slope which is derived from recommended practice in designing sprinkler systems for minimum surface runoff. These rates are generally consistent with the range of infiltration rates observed in actual field tests previously discussed. They have been adopted for use in estimating the maximum sustained application rates for each of the soil associations. An application rotation of 4 days has also been indicated in which the soil would be loaded for one day and rested for three days.

A summary of data from selected wastewater application sites is given in Table II-C-4. It can be seen that these sites cover a wide range of waste types, application rates and vegetative covers. Information on the success or shortcomings of each operation and the levels of treatment achieved is not available.

4 - Soil - Water - Vegetation Relationships

Removal of various constituents from the water depends upon the surface area of the soil particles and the soil flora and fauna past which the water moves, and the time required for the movement. Thus, soils which achieve acceptable removals usually contain clay and organic material as well as silt or sand. They fall generally into the categories sandy loam and silty loam.

The maximum infiltration rate of many agricultural soils exceeds the evapotranspiration requirement of the vegetation they support. Nearly all soils will support some type of vegetation, however sparse, but not



ESTIMATED MAXIMUM SOIL APPLICATION

Figure II-C-4

(Based on Ref. 25)

Table II-C-4

SUMMARY OF SELECTED LAND DISPOSAL OPERATIONS 1/

Location	Type of Waste	Application				Ground Cover
		Mode 2/	Rate	Period	Ft/yr	
Penn State College State College, Pa.	Domestic	SI	2"/acre-wk @ 0.25"/hr	32 wk-crops 52 wk-forest	5.3 8.7	Mixed crop land and forest land
Campbell Soup Co. Paris, Texas	Cannery	OR	2.5"/acre-wk summer. 1.25"/acre-wk winter; at 0.5"/day summer. 0.25"/day winter	52 wk	8.6	Crop land (hay)
Muskegon, Mich. (Under construction)	Municipal	SI	2"/acre-wk, max. 4"/wk rain plus spray	35 wk	11.7	Crop land (corn)
Flushing Meadows Project Phoenix, Az.	Municipal	RI	400'/acre-yr @ 2 wk wet followed by 10 days (summer) or 20 days (winter) dry-up	52 wk	400.0	Open basin with Bermuda grass cover
Santee, Calif.	Domestic	RI	110'/acre-yr intermittent spread and dry	52 wk	110.0	3-acre spreading area
Whittier Narrows Los Angeles, Calif.	Municipal	RI	13 mgd	52 wk	---	---
South Lake Tahoe, Calif.	Domestic	OR	4.5"/acre-wk @ 2 days spray, 4-5 days rest	Study periods winter and summer 1963-65	---	Forest land
North Lake Tahoe, Calif.	Domestic	RI	Approx. 1.25 mgd 17 acre site with 15,000 LF percolation trenches	52 wk	83.0	Volcanic cinder cone
Celotex Corporation L'Anse, Mich.	Industrial (insulation board)	SI	3.8"/acre-wk @.035"/hr 16 hr/day	24 wk	7.6	Crop land (Reed canary grass)

			tent spread and dry			area
Whittier Narrows Los Angeles, Calif.	Municipal	RI	13 mgd	52 wk	---	---
South Lake Tahoe, Calif.	Domestic	OR	4.5"/acre-wk @ 2 days spray, 4-5 days rest	Study periods winter and summer 1963-65	---	Forest land
North Lake Tahoe, Calif.	Domestic	RI	Approx. 1.25 mgd 17 acre site with 15,000 LF percolation trenches	52 wk	83.0	Volcanic cinder cone
Celotex Corporation L'Anse, Mich.	Industrial (insulation board)	SI	3.8"/acre-wk @.035"/hr 16 hr/day	24 wk	7.6	Crop land (Reed canary grass)
Seabrook Farms Seabrook, N. J.	Frozen vegetable	RI	10"/acre-wk @.25"/hr 5 days/wk	---	---	Original oak forest altered to marsh grasses
Westby, Wis.	Municipal	RF	21"/acre-wk, 2 wk on, 2 wk off	52 wk	46.0	Reed canary grass (burned each spring)
Sunkist Growers Inc. Corona, Calif.	Lemon processing	RF	6"/acre, load in 1 day, rest and dry 2 wk	14 wk canning season	3.5	Bare soil during spreading season. Crops planted during 38-wk dormant season
Campbell Soup Co. Napoleon, Ohio	Cannery (tomato)	OR	7"/acre-wk @.083"/hr 6 hr on, 6 hr off	50-day canning season	4.2	Reed canary grass, seaside bent & red top
Campbell Soup Co. Chestertown, Md.	Cannery (poultry)	OR	Similar to Napoleon Ohio	52 wk	30.4	Similar to Napoleon Ohio
Howard Paper Mills Urbana, Ohio	Industrial (paper)	SI	1.3"/acre-wk @0.2"/hr	52 wk	5.6	Alfalfa hay cover. Underdrains for recapture.
Sunapee State Park Mt. Sunapee, N.H.	Domestic	SI	2"/acre-wk @0.25"/hr	20 wk	3.3	Forested
Beardmore & Company Toronto, Ontario, Canada	Industrial (*annery)	SI	6"/acre-wk @0.2"/hr	30 wk	15.0	Reed canary ,bone and timothy grass
Shoemaker's Dairies Bridgeton, N.J.	Industrial (milk processing)	SI	0.2"/acre-wk @0.02"/hr	52 wk	0.9	Hay and grasses
Commercial Solvents	Industrial	SI	2"/acre in one 10-hr	52 wk	4.3	Bare ground

Howard Paper Mills Urbana, Ohio	Industrial (paper)	SI	1.3"/acre-wk @0.2"/hr	52 wk	5.6	**Alfalfa hay cover.** Underdrains for recapture.
Sunapee State Park Mt. Sunapee, N.H.	Domestic	SI	2"/acre-wk @0.25"/hr	20 wk	3.3	Forested
Beardmore & Company Toronto, Ontario, Canada	Industrial (tannery)	SI	6"/acre-wk @0.2"/hr	30 wk	15.0	Reed canary, bone and timothy grass
Shoemaker's Dairies Bridgeton, N.J.	Industrial (milk processing)	SI	0.2"/acre-wk @0.02"/hr	52 wk	0.9	Hay and grasses
Commercial Solvents Corp. Terre Haute, Ind.	Industrial (fermentation)	SI	2"/acre in one 10-hr spray followed by 2-wk rest	52 wk	4.3	Bare ground
H.J. Heinz Co. Salem, N. J.	Cannery (tomato)	SI	0.5"/acre-wk @0.03"/hr	Canning season	---	Reed canary grass
Riegel Paper Co. Hughesville, N.J.	Industrial (paper)	SI	3.2"/acre-wk @.2"/hr for 4 hr and 20-hr rest	52 wk	13.8	Grass
Green Valley Farms Avondale, Pa.	Cattle wastes	SI	2"/acre-wk @0.25"/hr	52 wk	8.7	Crop land (hay) in summer, forest in winter
Masonite Corp. Towanda, Pa.	Industrial (wall board)	SI	Approx. 0.5"/acre-wk @.05"/hr	52 wk	2.2	Reed canary grass

NOTES:

1/ From Ref. 16

2/ SI Spray irrigation
OR Overland runoff
RI Rapid infiltration
RF Ridge and furrow spreading

all soils can be successfully irrigated to maintain a desired vegetation. Extremely permeable soils (fine sand) in a free-draining profile will not retain water long enough to prevent wilting of vegetation, and extremely tight soils (clays) will not accept water fast enough to prevent wilting.

Areas having natural slopes in excess of ten percent have not been irrigated in the past because sufficient lands with flatter slopes have been available and are more economical to develop. It is technically feasible, however, to establish and maintain various vegetative covers with carefully controlled irrigation applications on ground slopes up to 30 percent. Although each plant species requires an individual environment for best growth, they can be grouped into categories which have similar characteristics and uses.

Four general categories of vegetation, shown in Table II-C-5, have been selected for the range of soils and slopes occurring in the sites investigated. With the exception of forests, these vegetative types have been successfully irrigated in California on the soil types shown.

The response of vegetation to applied water can be generalized as shown in Figure II-C-5. This relationship assumes that the vegetation receives adequate nutrients, sunlight and cultivation where required. Since the yield is nearly proportional to the nitrogen used by the vegetation, and the consumptive use can be computed from climatic factors, Figure II-C-5 gives a good indication of the nitrogen removal capacity of vegetation.

The wastewater application required by vegetation to achieve optimum growth (maximum yield) can be estimated from measurements of pan evaporation and precipitation at or near the location being investigated. Monthly estimates of these requirements are discussed in Section E.

5 - Soil - Water - Treatment Relationships

The extreme complexity of the physical, chemical and biological processes of the soil-water-plant systems precludes any precise definition of their quantitative relationships. It is possible, however, to identify some of the processes by which wastewater constituents will be changed in passing through a soil column.

Except for the nitrates and phosphates, the soluble salt fraction (anions) of the total dissolved solids will not be removed by the soil mantle. Although they will undergo chemical exchange and precipitation as wastewater passes through the soil, they will not be taken into the plant systems and cannot be allowed to accumulate in the soil root zone. If salts do accumulate, osmotic tensions that exceed the plant tolerances will develop. To control salt accumulation, annual applications of water in excess of that transpired by the vegetation must be applied. These applications dissolve accumulated salts and flush them out of the root zone and into the drainage system or receiving groundwater. Hence, over a period of time (one year or more) the salt flow must equal the salt inflow. Drainage water concentrations of these salts will, however,

Table II-C-5

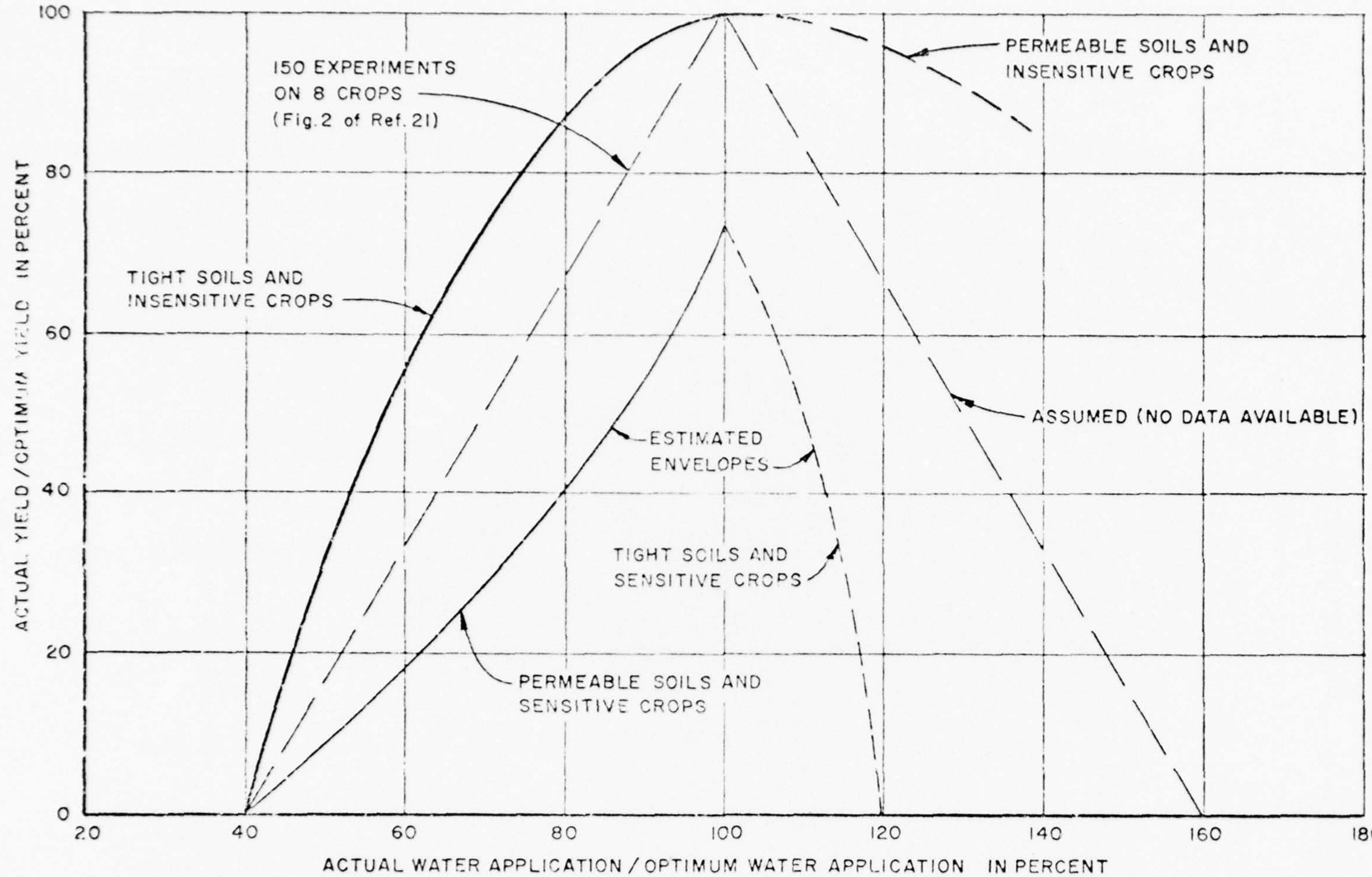
GENERALIZED SOIL - VEGETATION RELATIONSHIPS 1/

Vegetation Types	Soil Types
Forests Redwood Monterey Pine	Gravelly to clayey soils 3 feet or more in depth and located on steep uplands and terraces with 20 to 30 percent slopes. Generally but not always Class VI, Class VII and Class VIII soils.
Pastures Rye Fescue Bermuda Clover Brome	Sandy to clayey loams 3 feet or more in depth and located on basin rims, terraces and uplands with 10 to 20 per cent slopes. May also occupy cropland soils. Generally but not always Class III, Class IV and Class VI soils.
Crops Row Truck Orchard Vines Grain Alfalfa Rice	Sandy to clayey loams 5 feet or more in depth and located in basin alluvial fans and flood plains with 0 to 10 percent slopes. Generally but not always Class I, Class II and Class III soils.
Marsh Grasses 2/ Reed Canary Grass	Sandy to silty loams 5 feet or more in depth and located in basin alluvial fans with 0-2 percent slope. Generally but not always Class I soils.

NOTES:

1/ The potential land uses for the various soil types are given in more detail in Table II-E-2

2/ Rapid infiltration areas



GENERALIZED APPLICATION - YIELD RELATIONSHIP

Figure II-C-5

increase because of water losses through evaporation and transpiration.

A substantial portion of the total phosphorous can be removed by the soil and eventually used by the vegetation. The small particles of most soils are effective in removing phosphates through the sorption and biodegradation processes. Table II-C-7 gives average removal rates of phosphorous for various methods of application.

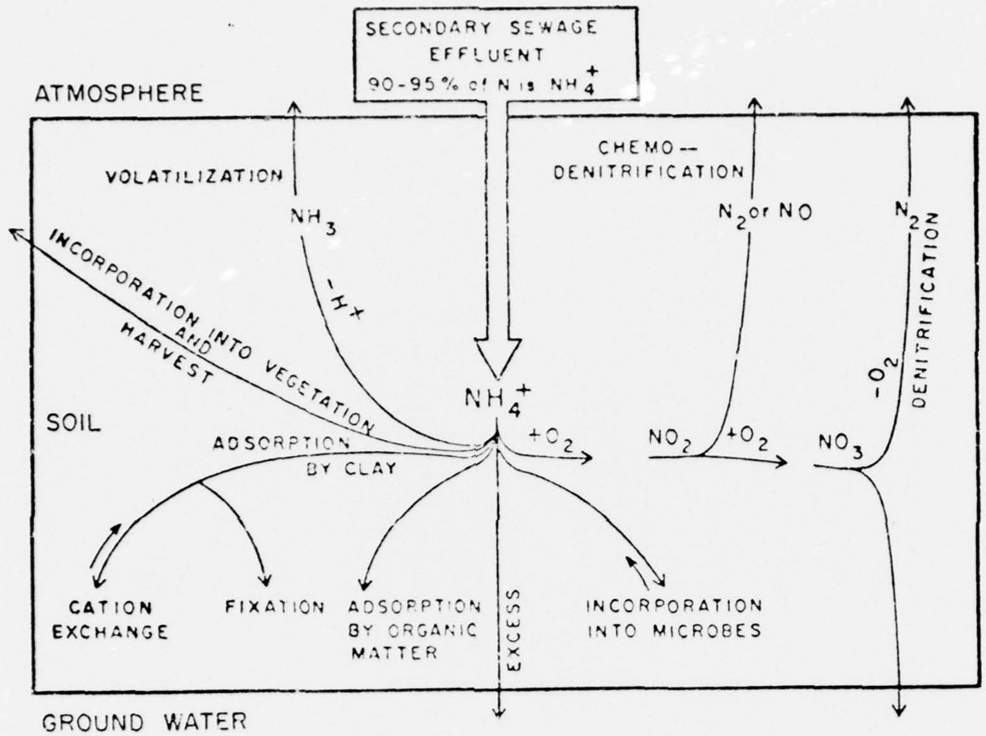
The various processes for removal of nitrogen by the soil-plant system are illustrated in Figure II-C-6. The quantity of plant uptake of nitrogen varies with the type of vegetation, season and the form of the nitrogen source (i.e., as organic ammonia or nitrate nitrogen). From experience with commercial fertilizer, the generalized annual plant use of applied nitrogen sources may be taken as 300 to 400 pounds per acre for optimum growth conditions. Any applied nitrogen in excess of these amounts must be volatized, denitrified or leached to the drainage system. The rates of volatization and denitrification for various applications of nitrogen sources are not known since such research has only recently been initiated. The University of California at Davis will start such a study in late 1972.

Figure II-C-7 gives the nitrogen removal relationship assumed for this study. It is not completely supported by the few experiments that have been reported in the literature but is however, rational and gives substantial weight to the effectiveness of nitrogen removal by the volatization and denitrification processes.

Table II-C-6 shows the effectiveness of various depths of soil in removing coliform organisms. Sub-surface drainage systems installed six feet below ground level will provide an adequate treatment depth and will also provide adequate groundwater level control for most of the Class I and Class II soils found in the wastewater application sites.

The large quantities of water proposed in Section E for rapid infiltration sites (90 feet per year) limit the types of ground cover suitable for use in these areas to marsh grasses. Some sort of cover is very desirable to remove nitrogen and phosphorous, to limit or prevent erosion and to enhance the appearance of the site. Ground cover will also act to reduce surface clogging and to maintain a porous soil structure, thus promoting infiltration. Bermuda grass has also been used successfully with high application rates at the Flushing Meadows site in Arizona.

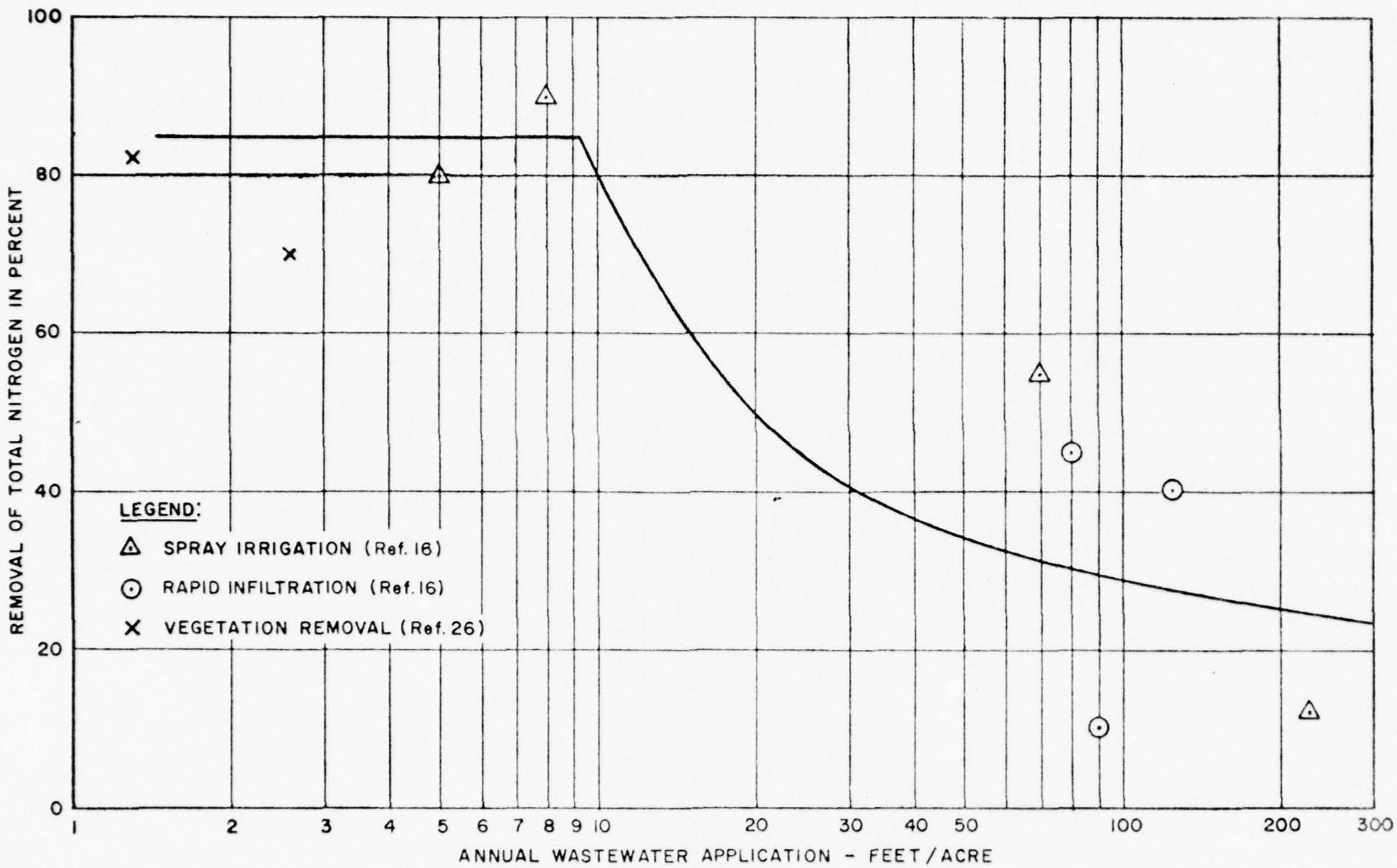
Very little is known about the ability of soils and plants to accumulate, assimilate and modify significant concentrations of heavy metals. This lack of knowledge and the known toxicity of GHM to plants,



NITROGEN TRANSFORMATIONS DURING LAND DISPOSAL OF WASTEWATER

Figure II - C - 6

(From Ref. 26)



ASSUMED NITROGEN REMOVAL RELATIONSHIP

Figure II - C - 7

Table II-C-6

DISTRIBUTION OF COLIFORM ORGANISMS IN
HANFORD FINE SANDY LOAM AT LODI, CALIFORNIA 1/

Basin	Sewage Effluent Spread	Average MPN at Indicated Depth						
		Surface	1 ft	2 ft	4 ft	7 ft	10 ft	13 ft
A	Primary	414×10^4	1.6	32 2/	0.6	0	0	---
	Final	179×10^3	1.2	285 2/	2.1	0	0	---
B	Primary	570×10^4	20	0	0	0	0	0
	Final	188×10^3	482	5.6	0.5	0.2	0.1	0
C	---	---	---	---	---	---	---	---
	Final	188×10^3	148	305	2.0	0.2	0.1	0.3
D	---	---	---	---	---	---	---	---
	Final	164×10^3	0.2	---	---	0	---	0

NOTES:

1/From Ref. 14, P.72.

2/ Sand channel from surface to 2-foot depth.

Table II-C-7 1/

REMOVAL EFFICIENCIES FOR LAND APPLICATION OF WASTEWATERS

	% Removal 2/		
	Spray Irrigation	Overland Runoff	Rapid Infiltration
Biochemical Oxygen Demand (BOD)	98+	98	80-85
Chemical Oxygen Demand (COD)	95+	92	50-60
Nitrogen (N)	85+	80	30-80 3/
Phosphorous (P)	99+	40-80	50-60
Metals	95+	50	50-60
Suspended Solids	99	94	99
Pathogens	99	99	99

NOTES:

1/ From Ref. 16, P. 30.

2/ The results for spray irrigation are modeled upon research accomplished at Penn State University. For overland runoff, the values listed for BOD, COD, N and suspended solids are reported values of an operation at Paris, Texas. All other values for overland runoff and rapid infiltration are estimates by the CRREL staff.

3/ See Fig. II-C-7.

animals and humans requires that industrial wastes be treated at their sources to a level consistent with normal municipal wastes.

Table II-C-6 shows the effectiveness of various depths of soil in removing coliform organisms. Sub-surface drainage systems installed six feet below ground level will provide an adequate treatment depth and will also provide adequate groundwater level control for most of the Class I and Class II soils found in the wastewater application sites.

Table II-C-7 gives the average removal efficiencies adopted for each of the wastewater constituents. The forests, pastures and crops are recommended for spray irrigation and the lands identified for marsh grasses (infiltration areas) may be either surface irrigated or spray irrigated. No sub-surface drainage systems would be installed in forest and pasture lands and closed sub-surface drainage systems would be used in the cropped and infiltration areas. However the closed sub-surface drainage systems would not be installed until groundwater levels have risen to within ten feet of the ground surface. A substantial part of the leachate from the forest and pasture lands would be expected to move laterally in the general direction of the cropped and infiltration areas where it could be collected by sub-surface drains or groundwater pumping.

In the absence of natural impermeable strata or a high groundwater table beneath any wastewater application area, comingling of the treated leachate and the groundwater must be expected. No known sub-surface drainage system can be designed to intercept all of the leachate for a reasonable cost. Therefore, where the quality of the groundwater would be significantly degraded by the uncontrolled leachate, pre-treatment of the applied water would be necessary. Sub-surface drainage systems in areas having an impermeable stratum or a groundwater table four to ten feet below the ground surface will be quite effective in collected leachate with only minor comingling of the groundwater.

D. SITE IDENTIFICATION

D. SITE IDENTIFICATION

The entire Study Area was systematically reviewed to determine general areas containing potential wastewater application sites. The boundaries of potential sites were identified and the procedures involved were documented. A representative approach was used in the evaluation of the fifty-three potential wastewater application sites identified in the Study Area. Using that approach, nine sites were selected which represent the characteristics of larger portions of the Study Area and the range of possible wastewater application objectives. This approach emphasized the characteristics of each selected site rather than its physical location.

1 - Site Identification Criteria

The following criteria were used to exclude lands from consideration for wastewater application:

1) All land areas having elevations greater than 1500 feet.

2) All land areas situated in national and state parks and national wildlife refuges (these may be reinstated).

3) All land areas in projected urban areas (year 2020).

4) All land areas having soils classified as Group D 1/ by the Soil Conservation Service. In addition, land areas having an identifiable hardpan layer or bedrock at a depth of less than four feet. (This criterion may be excepted where land areas can be successfully irrigated and drained.)

5) All lands in flood plains. (This criterion may be modified for land areas whose location and soils are highly desirable for wastewater application and which can be adequately protected from floods of reasonable frequency.)

6) Land areas of 5,000 acres or less or of insufficient capacity to accept a total wastewater application rate of at least five million gallons per day per mile from the source.

1/ As defined in the "National Engineering Handbook, Hydrology." Soil Conservation Service, United States Department of Agriculture.

The first criterion was based on the assumption that the required pumping head to lands above 1500 feet in elevation could not be justified. The second criterion assumed major legal and institutional problems. It was, however, not applied in selecting one site (Site No. 4) that represented a unique opportunity for the improvement of a wildlife habitat and recreation area. The third, fourth and fifth criteria are self-explanatory. The fifth criterion was not, however, applied in one site (Site No. 5) to show the probable effects of using the permeable soils types often found in flood plains. The sixth criterion was intended to eliminate small isolated sites which are distant from the nearest wastewater sources and consequently uneconomical to develop. This criterion did not, in fact, eliminate any identified sites from consideration.

2 - Screening Method

The method used to systematically review the entire study area was the development and analysis of a system of colored overlays based on 1:250,000 scale topographic maps available from the U. S. Geological Survey. A color photograph of each map with its overlays is included in this report. Colored projection slides of each map are also included for projection or additional prints.

The overlay system was selected for the following reasons:

1) The overlay system is easy to interpret. Excluded areas are clearly shown and exclusionary criteria are easily identified,

2) The overlay system is easily changed, and can quickly accommodate a reevaluation of criteria, and

3) The relative impacts of exclusionary criteria are clearly indicated.

3 - Maps and Overlays

The base maps used for the overlay system were U. S. Geological Survey maps of the Western United States at a scale of 1:250,000. Thirteen of these maps were used. For each map, five clear acetate overlays were prepared. On each clear overlay, colored film was applied to cover the appropriate characteristics with

the specified color. Each color represented one exclusionary criterion. The following overlays were used:

<u>Brown</u> - The brown overlay was used to represent all lands in the project area with an elevation above 1500 feet mean sea level. The boundaries of these areas were determined from the contours shown on the base maps.

<u>Red</u> - The red overlay was used to represent all soils judged inappropriate for wastewater application. They are those included in soil Group D specified by the Soil Conservation Service. These soils are defined as having very slow infiltration rates when thoroughly wetted. They include chiefly

1) clay soils with a high swelling potential,

2) soils with a high permanent water table,

3) soils with clay pan or clay layer at or near the surface, and

4) shallow soils over nearly impervious materials.

The areas in which these soils occur were determined using county soil maps.

<u>Blue</u> - The blue overlay was used to represent areas having a 1 in 100 year flood hazard.

<u>Yellow</u> - The yellow overlay represents urban areas projected to the year 2020. These urban areas were projected using data obtained from county and state planning reports.

<u>Green</u> - The green overlay represents national and state parks and National Wildlife Refuges. The boundaries of these areas were derived from the data shown on the base maps.

4 - Identified Sites

All of the colored overlays were assembled in position over the base maps. Those areas which could be considered as potential wastewater application sites were identified by determining the areas not covered by any color in the five overlays. The sixth criterion, that no land area less than 5,000 acres in size would be included as a potential application site, was then applied. Fifty-three land areas remained after the application of the Site Identification Criteria and were outlined on the base maps and numbered for identification. The approximate boundaries of each of the 53 sites are shown on Figure II-D-1 as well as on the colored projection slides. Site data is summarized in Table II-D-1.

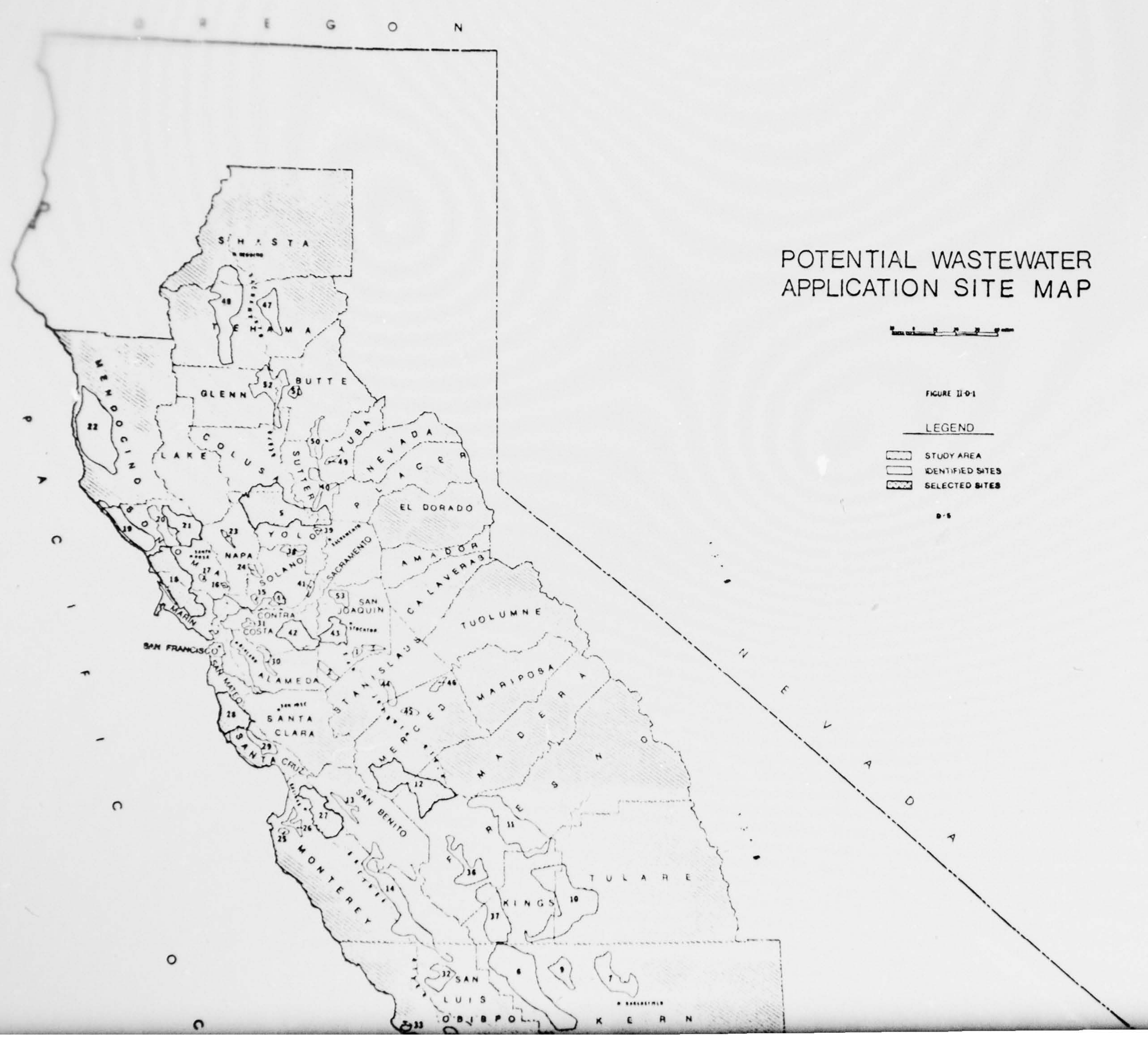
The information given for each site in Table II-D-1, supplemented by knowledge and judgments of the site characteristics, was used to select nine of the sites for detailed consideration. The nine sites (indicated in Table II-D-1 by heavy outlines) were selected for representing other sites and alternative development objectives. Evaluations of the nine Selected Sites are found in Section E of this report.

It should be noted that three potentially significant parameters were not explicitly considered in the selection of wastewater sites, and are outlined below:

1) No consideration has been given to provision of wastewater storage facilities in or near the selected sites. For the most part the selected sites include or are near fairly hilly areas and it is assumed in this report that storage facilities can be provided in any of the selected sites at a reasonable cost.

2) No relationships between the selected sites and the jurisdictions in which they occur have been studied. For example, some of the potential sites occur wholly or partially within existing irrigation districts, and it appears likely that some coordination of existing facilities would be possible and desirable.

3) No consideration has been given to ownership rights to the wastewater.


POTENTIAL WASTEWATER
APPLICATION SITE MAP
FIGURE II-D-1
LEGEND
STUDY AREA
IDENTIFIED SITES
SELECTED SITES
D-5
OREGON
NEVADA
PACIFIC OC
SHASTA
TEHAMA
GLENN
BUTTE
MENDOCINO
LAKE
COLUSA
SUTTER
YUBA
NEVADA
PLACER
EL DORADO
YOLO
NAPA
SONOMA
SOLANO
SACRAMENTO
AMADOR
CALAVERAS
TUOLUMNE
MARIN
SAN FRANCISCO
CONTRA COSTA
SAN JOAQUIN
ALAMEDA
SAN MATEO
SANTA CLARA
SANTA CRUZ
STANISLAUS
MERCED
MARIPOSA
MADERA
FRESNO
SAN BENITO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN


STUDY AREA
IDENTIFIED SITES
SELECTED SITES
N E V A D A
A R I Z O N A
M E X I C O
P A C I F I C O C E A N
PBQ&D, Inc.
EL DORADO
AMADOR
CALAVERAS
TUOLUMNE
MARIPOSA
MADERA
FRESNO
TULARE
KINGS
KERN
SAN LUIS OBISPO
MONTEREY
SAN BENITO
MERCED
STANISLAUS
SAN JOAQUIN
SACRAMENTO
YOLO
SOLANO
NAPA
MARIN
CONTRA COSTA
ALAMEDA
SANTA CLARA
SANTA CRUZ
SAN MATEO
SAN FRANCISCO

Table II-D-1

PRELIMINARY AND SELECTED WASTEWATER APPLICATION SITE DATA

Site No.	Location Data: County	Approximate Distance (miles) and Direction of Site from: Nearest Town	Nearest Wastewater Source	Gross Area 1/ (acres)	Elevation Range (MSL)	Dominant Soil Associations 2/	Rare or Endangered Animals 3/	Estimated Future Land Use 4/	Remarks
1	San Joaquin	4S - Manteca	15S - Stockton	20,000	20-30	Dinuba, Valdez-Columbia, Tujunga-Hanford	GGS	C,IF	Surface & spray application, tile drains, favorable location groundwater could be collected
2	San Joaquin	9SW - Tracy	23SW - Stockton	24,000	600-1411	Linne-Altamont	GGS, ASR	F,P	Altamont soil may have too low a K coefficient. Unfavorable because of slopes combined with slow infiltration rate
3	San Joaquin	8SE - Manteca	17SE - Stockton	13,000	55-100	Tujunga-Hanford, Dinuba	GGS	C,IF	OK for waste disposal, groundwater reclamation required
4	Solano	12SE - Fairfield	12NE - Concord 30NE - Oakland	12 000	0-10	Valdez	GGS SSS	P,C,IF	Grizzly Island Wildlife Refuge. Little soil filtering constituent and water uptake in food chain. Rep. of wetland, marsh & pond applications. Close to several sources.
5	Yolo	12NW - Woodland	28NW - Sacramento	356,000	40-1500	Brentwood-Yolo, Schorn, Marvin-Rincon-Tehama, Dibble-Millsholm	GGS	F,P,C,IF	Water deficient area. Part of USBR west Sacramento Canal Unit. Dunnigan Hills are possible forest sites. Gypsum applied to alkali areas may improve infiltration rates. Includes rice growing applications.
6	Kern	4-50NW - Ford City	150SE - San Jose	360,000	250-1500	Panoche, San Emigdio-Hesperia, Kettleman	CC, SKF, GGS	F,P,C,IF	Selected areas favorable. Reclamation required-both salinity & boron problems.
7	Kern	12N - Bakersfield	210SE - Stockton	122,000	400-1500	Delano-Adelanto, Kettleman, Delano-Cuyama	BLL, GGS, SKF	F,P,C	Selected areas would be favorable.
8	Kern	22S - Bakersfield	240SE - Stockton	145,000	400-800	San Emigdio-Hesperia, Nacimiento-Linne, Kettleman	GGS, BLL, SKF	P,C,IF	Groundwater salinity & boron, require leaching & collection for water
9	Kern	8W-Wasco	200SE - Stockton	59,000	230-300	Panoche, Traver-Pond, Hesperia-Hanford	GGS, BLL SKF	P,C,IF	Panoche series generally satisfactory, lethent less desirable
10	Kings/Tulare	7NW - Pixley	180SF - Stockton	340,000	220-450	Temple-Traver, Traver-Pond, Fresno-El Paco	GGS, BLL SKF	P,C,IF	Soils only fair in relation to other sites. Not desirable.
11	Fresno	Caruthers in site	130SE - Stockton	250,000	180-280	Hesperia-Hanford, Traver-Pond Fresno-El Paco	FKR, SKF, GGS	P,C,IF	Hesperia-Hanford series may have low infiltration rates for reasons other than sodium or alkalai, hence infil. rates will always be low.
12	Merced/Fresno	12SW - Dos Palos	90S-Stockton	231,000	180-1500	Panoche, Lost Hills, San Emigdio, Oxalis, Kettleman	GGS, SKF	F,P,C,IF	Panoche is a prime agric. soil. Possible infil., salinity & down-slope drainage problems. A good drainage system would be important. Possible forest application
13	San Benito	12SE-Hollister	70SE-San Jose	35,000	800-1500	San Benito-Diablo, Hanford, Sorrento-Mocho		F,P	Serious seismic creep problems locally. Pg-Rincon series on smaller slopes. Area of suitable land quite limited in contiguous sections.
14	San Benito/Monterey/San Luis Obispo	Upper Salinas Valley	115SE-San Jose	263,000	300-1500	Linne-Diablo, Linne-Shedd, Salinas-Mocho, San Benito, McCoy-Sesame		F,P,C	May leach Hg from local cinnibar deposits. San Andreas fault in this valley. Combined slope, infil. & drainage problems make area questionable.
15	Solano	5NE-Vallejo	12N-Concord	6,000	400-1129	Dibble-Los Osos		P	Good access to Suisun Marsh & lower San Joaquin river. Infil-

10	Kings/Tulare	7NW - Pixley	180SE - Stockton	340,000	220-450	Temple-Traver, Traver-Pond, Fresno-El Paço	GGS,BLL SKF	P,C,IF	Soils only fair in relation to other sites. Not desirable.
11	Fresno	Caruthers in site	130SE - Stockton	250,000	180-280	Hesperia-Hanford, Traver-Pond Fresno-El Paco	FKR,SKF, GGS	P,C,IF	Hesperia-Hanford series may have low infiltration rates for reasons other than sodium or alkalai, hence infil. rates will always be low.
12	Merced/Fresno	12SW - Dos Palos	90S-Stockton	231,000	180-1500	Panoche, Lost Hills, San Emigdio, Oxalis, Kettleman	GGS,SKF	F,P,C,IF	Panoche is a prime agric. soil. Possible infil., salinity & down-slope drainage problems. A good drainage system would be important. Possible forest application
13	San Benito	12SE-Hollister	70SE-San Jose	35,000	800-1500	San Benito-Diablo, Hanford, Sorrento-Mocho		F,P	Serious seismic creep problems locally. Pg-Rincon series on smaller slopes. Area of suitable land quite limited in configuous sections.
14	San Benito/Monterey/San Luis Obispo	Upper Salinas Valley	115SE-San Jose	263,000	300-1500	Linne-Diablo, Linne-Shedd, Salinas-Mocho, San Benito, McCoy-Sesame		F,P,C	May leach Hg from local cinnibar deposits. San Andreas fault in this valley. Combined slope, infil. & drainage problems make area questionable.
15	Solano	5NE-Vallejo	12N-Concord	6,000	400-1129	Dibble-Los Osos		P	Good access to Suisun Marsh & lower San Joaquin river. Infil. rates of these soils borderline.
16	Napa	3W-Napa	3W-Napa	3,000	100-500	Millsap		P	Limited disposal, but has other attributes.
17	Sonoma	4W-Sonoma	16SE-Santa Rosa	5,000	400-1500	Goulding-Toomes		P	Too steep.
18	Marin/Sonoma	8W-Sebastopol 6W-Petaluma	16SW-Santa Rosa 24NW-San Rafael	196,000	100-1500	Los Osos, Steinbeck-Los Osos, Goldridge		F,P,C	Represents issues of wastewater application to water supply & potential redwood forest area.
19	Sonoma/Mendocino	3-45NW-Monte Rio	35NW-Santa Rosa	134,000	100-1500	Hugo-Laughlin-Josephine, Yorkville-Sutherlin, Goldridge		F,P	Hugo soils may be good redwood habitat. The Gravenstein belt-prime agric. land. Only shallow slopes worth of consideration.
20	Sonoma	5W-Healdsburg	15NW-Santa Rosa	71,000	200-1500	Los Gatos-Henneke-Maymen, Hugo-Laughlin-Josephine		F,P	Laughlin is good timber soil. Excessive slopes, low infil. & higher rainfall not good combin.
21	Sonoma	6E-Healdsburg 12N-Santa Rosa	12N-Santa Rosa	125,000	100-1500	Yolo-Cortina-Pleasanton, Spreckels-Yelta, Hugo-Laughlin Josephine		F,P,IF	Water deficient area. Close to source. Potential farming, forest & recreation uses.
22	Mendocino	24SE-Fort Bragg	80NW-Santa Rosa	330,000	100-1500	Hugo-Josephine, Mendocino-Empire-Caspar		F	Poor soils; steep.
23	Napa	8NE-St. Helena	30NE-Santa Rosa	11,000	600-1500	Dibble-Los Osos, Esparto-Zamora		F,P,C	Water deficient area
24	Napa	9NW-Fairfield	25N-Concord	6,000	200-1500	Dibble-Los Osos		F,P,C	Small poor soils
25	Monterey	4SE Carmel	70S-San Jose	9,000	100-1500	Santa Lucia, Cleneba-Sheridan		F	Small distant poor soils
26	Monterey	10E-Carmel	60S-San Jose	34,000	100-1500	Santa Lucia-Gazos, Antioch-Gloria, Arnold		F,P,C,IF	Possible barrier to block sea-water intrusion into Salinas Valley.
27	Monterey/San Benito	6E-Salinas	60S-San Jose	141,000	100-1500	Arnold, McCoy, Vista, Chualar		F,P,C,IF	Local ground& surface water high in TDS. Represents issues of application to row crops eaten raw, & possible ground-water replenishment to block salt water intrusion near Salinas.
28	San Mateo	11SW-Redwood City	25S-San Francisco	127,000	600-1500	Lobitos-Gazos, Hugo-Butano-Josephine	SGS	F,R,C	A close-in site. Potential application for forest, recreation and water supply uses.
29	Santa Clara/ Santa Cruz	8N-Santa Cruz	24S-San Jose	49,000	400-1500	Hugo-Butano-Josephine, Arnold-San Andreas		F,P,C	Poor soils, steep
30	Alameda	3E-Castro Valley	20SE-Oakland	27,000	500-1500	Los Osos-Millsholm	ASR	F,P,C	Includes Chabot reservoir
31	Contra Costa	3N-Lafayette	6 W-Concord	10,000	800-1400	Los Osos-Millsholm	ASR		Includes Posiones reservoir Briones Regional Park, reservoir
32	San Luis Obispo	12NE-Atascadero	150SE-San Jose	61,000	1000-1500	Nacimiento-Linne		F,P,C	Steep, fair soils
33	San Luis Obispo	8SW-San Luis Obispo	170SE-San Jose	9,000	100-1300	Santa Lucia, Sorrento-Panoche		F,P	Distant, good soils
34	San Luis Obispo	6SE-Fair Oaks	180SE-San Jose	26,000	0-500	Oceano-Marina, Sorrento-Mocho		P,C,IF	Distant
35	San Luis Obispo	13E-Fair Oaks	180SE-San Jose	44,000	600-1500	Santa Lucia, Sorrento-Panoche		F,P	Distant, good soils
36	Fresno	12NE-Coalinga	130SE-San Jose	128,000	250-1000	Panoche, San Emigdio, Cima-Tumey	CC,BLL, GGS,SKF	F,P,C,IF	Short of water, good soils
37	Kings/Fresno	9E-Avenal	160SE-San Jose	169,000	300-1500	San Emigdio, Kettleman, Oxalis	GGS,CC BLL,SKF	F,P,C,IF	Good agricultural soils.

29	Santa Clara/ Santa Cruz	8N-Santa Cruz	24S-San Jose	49,000	400-1500	Hugo-Butano-Josephine,Arnold-San Andreas		F,P,C	Poor soils, steep
30	Alameda	3E-Castro Valley	20SE-Oakland	27,000	500-1500	Los Osos-Millsholm	ASR	F,P,C	Includes Chabot reservoir
31	Contra Costa	3N-Lafayette	6 W-Concord	10,000	800-1400	Los Osos-Millsholm	ASR		Includes Posiones reservoir Briones Regional Park,reservoir
32	San Luis Obispo	12NE-Atascadero	150SE-San Jose	61,000	1000-1500	Nacimiento-Linne		F,P,C	Steep, fair soils
33	San Luis Obispo	8SW-San Luis Obispo	170SE-San Jose	9,000	100-1300	Santa Lucia,Sorrento-Panoche		F,P	Distant, good soils
34	San Luis Obispo	6SE-Fair Oaks	180SE-San Jose	26,000	0-500	Oceano-Marina, Sorrento-Mocho		P,C,IF	Distant
35	San Luis Obispo	13E-Fair Oaks	180SE-San Jose	44,000	600-1500	Santa Lucia,Sorrento-Panoche		F,P	Distant, good soils
36	Fresno	12NE-Coalinga	130SE-San Jose	128,000	250-1000	Panoche,San Emigdio, Cima-Tumey	CC,BLL, GGS,SKF	F,P,C,IF	Short of water, good soils
37	Kings/Fresno	9E-Avenal	160SE-San Jose	169,000	300-1500	San Emigdio,Kettleman, Oxalis	GGS,CC BLL,SKF	F,P,C,IF	Good agricultural soils.
38	Solano	4N-Dixon	20W-Sacramento	30,000	40-120	Yolo-Zamora		P,C	Close, good soils
39	Sacramento/Yolo	8NW-Sacramento	8NW-Sacramento	9,000	15-30	Lang-Columbia, Valdez-Merritt		C,IF	Prime agricultural land
40	Sutter/Yolo/Yuba	3-26S-Yuba City	10NW-Sacramento	80,000	15-50	Wyman-Vina, Columbia-Ramada	GGS	P,C,IF	Prime agricultural land.
41	Solano	6NE-Rio Vista	25SW-Sacramento	9,000	0-10	Egbert		C,IF	Small,close
42	Contra Costa	6S-Antioch	15SE-Concord	108,000	50-1200	Altamont-San Benito-Linne	ASR	F,P,C,IF	Moderate erosion hazard. Potential recreation & wildlife enhancement.
43	San Joaquin	10SW-Stockton	10SW-Stockton	62,000	-5-15	Ryde-Egbert, Staten-Venice, Valdez-Columbia	GGS	P,C,IF	Site may be used for marsh wetlands or ponds,also representative of delta agric. High groundwater. Levees to protect from floods. Moderate to high wind erosion hazard.
44	Stanislaus/ Merced	5SW-Turlock	40SE-Stockton	33,000	50-100	Hilmar-Delhi, Quimbe-Hanford	BLL,GGS	C	Distant, good soils
45	Merced	5SW-Livingston	60SE-Stockton	15,000	100-130	Hilmar-Delhi	BLL,GGS	C	Distant, level
46	Merced	13NE-Atwater	60SE-Stockton	16,000	150-200	Snelling-Greenfield, Hanford-Grangeville	BLL,GGS	P,C	Distant, good soils, level
47	Tehama	10NE-Red Bluff	120NW-Sacramento	82,000	400-1500	Toomes-Supan		F,P	Steep, poor soils
48	Shasta/Tehama	10W-Red Bluff	100NW-Sacramento	300,000	300-1200	Newville-Nacimiento		F,P,C	Severe erosion if overgrazed.
49	Yuba	6NE-Marysville	50NW-Sacramento	8,000	50-200	Mine-Tailings, Columbia		P,C,IF	Soils would provide little treatment
50	Sutter/Yuba/ Butte	4-24N-Yuba City	50N-Sacramento	57,000	50-100	Tailings-Riverwash, Wyman-Vina, Columbia		P,C,IF	Soils would provide little treatment
51	Butte	6SE-Chico	70NW-Sacramento	16,000	100-200	Vina-Farwell		P,C	Distant, poor soils
			70NW-Sacramento	142,000	50-250	Columbia		P,C,IF	Distant, good soils
53	San Joaquin	6W-Lodi	12NW-Stockton	36,000	0-35	Hanford-Greenfield		P,C,IF	Level, good soils

NOTES:

1/ The gross areas of selected sites are based on more detailed map studies.

2/ See Table II-E-2 for more complete soil association descriptions.

3/ GGS - Giant Garter Snake
SGS - San Francisco Garter Snake
ASR - Alameda Striped Racer
BLL - Blunt-nosed Leopard Lizard
CC - California Condor
SSS - Suisun Song Sparrow
FKR - Fresno Kangaroo Rat
SKF - San Joaquin Kit Fox

A more complete identification of rare or endangered plant and animal species and unique historic, archeologic, scenic and geologic locations is given elsewhere in the report.

4/ F - Forests (Redwood and Monterey Pine)
P - Pasture
C - Crops (Mixed)
IF - Infiltration Area

☐ Site selected for more detailed evaluation.

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5 - Development Objectives

Each of the nine sites selected for further evaluation has individual characteristics which will permit wastewater treatment and, with managed wastewater application and drainage, could generate a desired environmental and/or economic benefit. The opportunities for achieving objectives in the nine sites are expected to be representative of opportunities if all 53 screened sites were evaluated.

Site No. 4. This site was selected to represent the opportunity for enhancing a wildlife habitat. The site includes the Grizzly Island Wildlife Refuge which is now managed solely as a waterfowl habitat. Water is diverted into portions of the site from Montezuma Slough to create salt marshes and ponds. Drainage is accomplished by surface drains and pumping back to Suisun Bay.

The site has little or no potential for agricultural purposes because of tight soils with poor drainage characteristics. The nearest source of wastewater is Concord (Contra Costa County), 12 miles southwest of the site.

The Bureau of Reclamation has recently completed a study to provide water for irrigation of a strip of land to the east of Montezuma Slough and to provide for freshwater inflows into the slough areas behind Grizzly Island to provide a more suitable natural habitat for wildlife. The Suisun Soil Conservation District has been active in the development of plans to maintain an adequate habitat for the large numbers of waterfowl that come through this area. Careful consideration should be given to the quality of any water that is applied to Site No. 4 so that it will not interfere with the growth of the plant foods for these waterfowl and especially with the waterfowl themselves.

Site No. 5. This site is the largest of the nine sites and includes a variety of land types. The major features are the Dunnigan Hills, the Cache Creek Valley, the Sacramento Valley lands and a portion of the Yolo Bypass. The opportunities of development are, respectively, irrigated pasture and/or forests, orchard production with streamflow and groundwater augmentation, and general irrigated cropping and rice production.

The nearest major source of wastewater is Sacramento, 20 miles southeast of the site.

There have been proposals for two dams and reservoirs in the Cache Creek Valley that would be part of the State Water Plan.

Indian Valley Dam is a locally sponsored project (Yolo County) that has federal and state support. The other potential site is the Wilson Valley Dam.

Another point to be noted is that the Sacramento Valley and Yolo Bypass intersect this area. Special consideration of the advantages and disadvantages of using that portion of the area in the Bypass would be considered.

At present there is an overdraft of the groundwater aquifers in the area. This is causing great concern among the water users and they are seeking supplemental water from the proposed Tehama-Colusa Canal.

Site No. 12. This site south of Los Banos and west of Firebaugh on the west side of the San Joaquin Valley is on the easterly slope of the Diablo range and includes, in particular, the Ortigalita Creek basin. In addition, it includes large areas of irrigated cropland and rangelands on alluvial fans at the base of the hills. It is considered representative of other areas on the west side of the San Joaquin Valley. Parts of this area are already served by the Delta-Mendota Canal and the California Aqueduct and the area is traversed by Interstate Highway 5. The steep uplands of this site offer an opportunity for additional development in irrigated cropland. There is a definite possibility that difficult drainage problems would exist in the lower part of the area if heavy water applications are made further uphill. The nearest source of wastewater for this site would be Contra Costa County or the area around Stockton. The relationship between transmission distance and economics of large scale development can be evaluated.

Site No. 18. This site is in Marin County north of Mt. Tamalpais and in Sonoma County south of the Russian River. It includes the basins of Nicasio Creek, Walker Creek, Estero Americano and Salmon Creek. The basin of San Antonio Creek is excluded because of poor soil conditions. The site is representative of various coastal and coast range sites. It offers a potential for development using redwood or Monterey pine forests. Related to this forestry potential are various uses for recreation or open space for which the area is generally designated in the appropriate county plans. Also related is a possibility for stream flow augmentation by the application of more water than normally occurs from rainfall and by restoring the forest cover. In the southern part of the area the principal application may be pasture land irrigation. Drainage of the wastewater application to the southern part of the area would be into the basin tributary to

the water supply reservoir near Nicasio which raises the issues and technical problems of the application of wastewater into a drainage basin from which water supply is extracted. The wastewater for this area would be transported from the developed areas of southern and central Marin County and central Sonoma County.

There are considerable orchards and small farms in the northern part of this area. The rest of the area is comparatively dry and used mostly for grazing. The southern sections of the site have been the subject of a great deal of controversy in master planning for the future with emphasis on open space.

Some consideration has been given to the construction of a dam and reservoir on Walker Creek to develop a better water supply for northern Marin County and the Marin Municipal Water District.

Site No. 21. Three valley areas in the vicinity of Healdsburg comprise this site. These valleys are Alexander Valley, Knights Valley and the Russian River Valley in the vicinity of Windsor. These valley areas are considered representative of a number of interior valleys in the coast range. They offer potential for irrigation of existing crops and new irrigation of forest area. Related to this is possible stream flow augmentation of the Russian River south of Healdsburg, particularly for recreational use during the summer season. Also significant in this area is a potential for augmentation of groundwater supplies for water pumped from this area into the domestic supply systems for communities to the south. Nearest wastewater applied to this site would come from the areas around Santa Rosa and Healdsburg.

The Russian River in this area furnishes the main source for irrigation of the many orchards and vineyards. Some areas pump directly from the river and others from wells drawing on the river. The river is supported in dry season by releases from Coyote Dam in the vicinity of Ukiah. The Corps of Engineers is currently constructing a dam on Dry Creek just to the west of this area which will control flows downstream from its mouth using the releases in the summertime to maintain adequate flows in the river and to provide for the water supply for the Sonoma - North Marin area from Ranney wells in the river bottom.

The Corps of Engineers has an authorized project to construct a dam in the Knights Valley area that would regulate Franz and Maacama Creeks. This reservoir would inundate a portion of the eastern subsections of the area in Knights Valley.

Site No. 27. This site includes the Gabilan Creek Basin and the easterly side of the Salinas Valley south from Salinas to near Soledad, including Quail and McCoy Creeks. It represents a potential area for managed forests, particularly of Monterey pine, and also for irrigated crops on the valley floor. Application of wastewater for irrigation could continue this type of agricultural activity and at the same time diminish or reverse the salt water intrusion into the area caused by excessive pumping for irrigation. The source of wastewaters for Site 27 would probably be from the Monterey Bay area or the southern portion of the Study Area.

Plans for the San Felipe Project by the Bureau of Reclamation include diversion of irrigation water from the Central Valley to the northern part of this area. Many of the present crops probably could not use wastewater for irrigation since they are leaf-type crops; however, the possibility of shifting to crops that could be irrigated with wastewater would be investigated.

The Corps of Engineers is currently doing a flood control study of the Salinas River Valley which may propose some new works. Flows in the lower river area may be affected. Presently some areas along the river edge of Sub-Area 27.5 are subjected to flooding during heavy winter storms.

Site No. 28. This site includes most of the southwest part of San Mateo County. It represents an area close to substantial urban development with potential for developing or improving redwood forests for commercial or recreational use. In addition, recreational use may be further enhanced by stream flow augmentation. The nearest source of water for this area would be from West Bay communities.

There has been considerable interest in San Mateo County to maintain the lands on the ocean side of the county in their natural states. Local water supplies for municipal and agricultural use are generally deficient in this area. The Corps of Engineers is investigating dams on Pescadero Creek to provide for a water supply north to Half Moon Bay. Because of the presence of several groves of natural Redwoods in this area, it would seem to be a good possibility for Redwood culture.

Site No. 42. This site lies in Contra Costa County east of Mt. Diablo and includes the Marsh and Kellogg Creek Valleys, Deer Valley and the forebays for the Delta-Mendota Canal and the California Aqueduct. It offers potential development for recreation

and open space areas, forested lands and wildlife habitats. With adequate wastewater treatment, an additional possibility is the direct delivery of effluent to the forebays for use in either of the canals. Of special concern in this area is the water quality relative to the reservoir on Marsh Creek and the proposed reservoir on Kellogg Creek. The nearest sources of wastewater for this area would be from the Antioch, Clayton or Stockton areas.

There are several special considerations for this site. The Clifton Court area is a forebay for the State Water Project and, therefore, the quality of the wastewater drainage must be given careful consideration because this forebay is a freshwater supply for the Delta Mendota Canal (as well as the California Aqueduct) under the Peripheral Canal concept for a cross-delta facility. The Delta Mendota Canal is a U. S. Bureau of Reclamation facility.

The proposed Kellogg Reservoir on Kellogg Creek is intended to be a water supply project and has been under study by the Bureau of Reclamation and the Contra Costa Water District. There is no authorized plan at the present time but it has been discussed in connection with the total State water resources development.

The Contra Costa County Water Quality Study (Ref. 4) considered, as one of the alternatives for the central and eastern County, transporting the water to the east and treating it for disposal in the Delta area and, therefore, it required high levels of treatment to remove all toxicants and biostimulants. The alternative included ponding for tertiary treatment with ultimate use for irrigation or for discharge into the estuary to assist in salinity repulsion (i.e., to increase freshwater outflow).

The previously noted Marsh Creek Project is a flood control project sponsored by the Contra Costa County Flood Control District.

State Water Resources Control Board demands for early action by industries in the Antioch area have caused considerable work by the individual industries. There is interest in a subregional plan that extends farther east than the first stage proposal of the Brown and Caldwell study (Ref. 4). This plan proposed to start at the Antioch Bridge and extend west to include the City of Antioch. The Central Valley Regional Water Quality Control Board is concerned with the treatment facilities of the cities of Oakley and Brentwood and desires some system to upgrade these plants, preferably to combine them into a central plant.

Site No. 43. This site includes Union Island and Roberts Island southwest of Stockton. It represents the large flat areas currently being formed in the Sacramento-San Joaquin Delta. It has a high water table which is expected to limit the vertical flow of water applied to the surface. However, it appears quite possible that water could be applied to the lands and recovered by means of drains and pumping in the area. This is the current method of irrigation and drainage now used. The use of wastewater in this area could provide an excellent source of irrigation water as an alternative to river flow and pumping from wells. Nearest sources of wastewater for Site 43 are Antioch, Clayton and Stockton.

Most of the Delta islands are leveed against the river and the winter floods. They contain primarily peat soils and are sinking each year as the peat tends to oxidize. Most of the general area is underlain with connate water. In addition, some of the deep aquifers are becoming more saline.

The San Joaquin River and the other rivers that cross through this area have serious water quality problems now, particularly in dissolved oxygen, so that discharges from a wastewater system would have to be of high quality to avoid compounding existing problems.

The proposed Peripheral Canal will come through this area and will transport fresh water to the Clifton Court forebay from the Sacramento River. It is intended that it would have some outlets to provide fresh water inflows into the Delta. Any new water importation schemes will have to demonstrate that the water quality will not be further deteriorated.

A major plan for the drainage of the area to the south of Site 43 incorporates the San Joaquin Master Drain or the San Luis Drain. This project proposes to collect the sub-drainage water from irrigated lands in the San Joaquin Valley, transport it to the Delta, and, after adequate treatment to reduce deleterious substances, discharge into the estuary. Present plans locate the outfail in the vicinity of Antioch. A test facility at Firebaugh has been in operation for about two years in an effort to determine what level of treatment is required for agricultural wastewater.

6 - Land Uses

Four major types of land uses are outlined in Section E of this report for the nine selected sites:

1) forest plantations (redwood and Monterey pine),

2) pastures,

3) crops (orchard, field, truck, etc.), and

4) high-rate infiltration basins (marsh grasses).

These land uses differ significantly in the manner in which wastewater is applied, constituents are removed and drainage water is collected and reused. Estimates of potential economic feasibilities for each land use are not discussed in this report.

Wildlife enhancement as a potential land allocation objective is discussed in Sections E and G.

7 - Correlation of Sites

The Soil Distribution Representivity Matrix shown in TableII-D-3 indicates the degree of correlation of soil capability classes (for definitions of capability classes, see Table II-C-2) of the nine evaluated sites and the 53 sites identified as potential wastewater sites. Each correlation is expressed as a percentage based on the estimated soil capability class distributions shown in Table II-D-2. The maximum correlation value is 100 percent, as indicated for the correlation of a single selected site, and a correlation of 0 percent indicates that no soil capability class was common to both sites. The soil distributions of the nine selected sites are independent variables in the correlation process and the soil distributions of the 53 potential sites are compared as dependent variables. Therefore, the two values shown for the correlation of one selected site with another selected site may differ in the two positions in the table. The matrix should be interpreted as indicating the percentage of total area of a potential wastewater site that exhibits the same capability class distribution pattern as the correlated selected site.

It should be noted that this matrix indicates only soil distribution correlations. Relative site sizes and distances from the nearest wastewater sources are given in Table II-D-1. A site

Table II-D-2

ESTIMATED SOIL CAPABILITY CLASS DISTRIBUTIONS
(% OF TOTAL SITE AREA)

Site	CAPABILITY CLASS							
	I	II	III	IV	V 1/	VI	VII	VIII
1		35	65					
2				10		90		
3		95	5					
4			33			67		
5	19	18	18	23		13	6	3
6	45	30					25	
7	10	25	25				40	
8		80	15				5	
9	5	92	3					
10		95	5					
11	5	65	30					
12	38	9	14	5		1	32	1
13		20				45	35	
14	5	5	5	10		60	15	
15						100		
16		10		90				
17			40			60		
18		13	1	20		58	7	1
19						20	80	
20						50	50	
21	2	20				18	60	
22		1		7		77	15	
23		27		3		70		
24		20				80		
25							45	55
26	5	5		5		10	75	
27	16	7	10	4		19	32	12
28		6	7	4		20	62	1
29			3	4			90	3

17			40			60		
18		13	1	20		58	7	1
19						20	80	
20						50	50	
21	2	20				18	60	
22		1		7		77	15	
23		27		3		70		
24		20				80		
25							45	55
26	5	5		5		10	75	
27	16	7	10	4		19	32	12
28		6	7	4		20	62	1
29			3	4			90	3
30	2						98	
31							100	
32		5	7	38		50		
33		10				40	50	
34	5	20		50		5		20
35		5				20	75	
36	60					3	37	
37	30	17	3				50	
38	70	30						
39		45	20	35				
40	35	20	40	5				
41			100					
42	19		2	28		25	22	4
43		17	83					
44		45	55					
45			100					
46	15	50	15			20		
47						2	98	
48			3	22		75		
49		55						45
50	60	11	11	10				8
51	80		18				2	
52	30	40	25	5				
53		55	45					

1/ Capability class V not included in County Reports.

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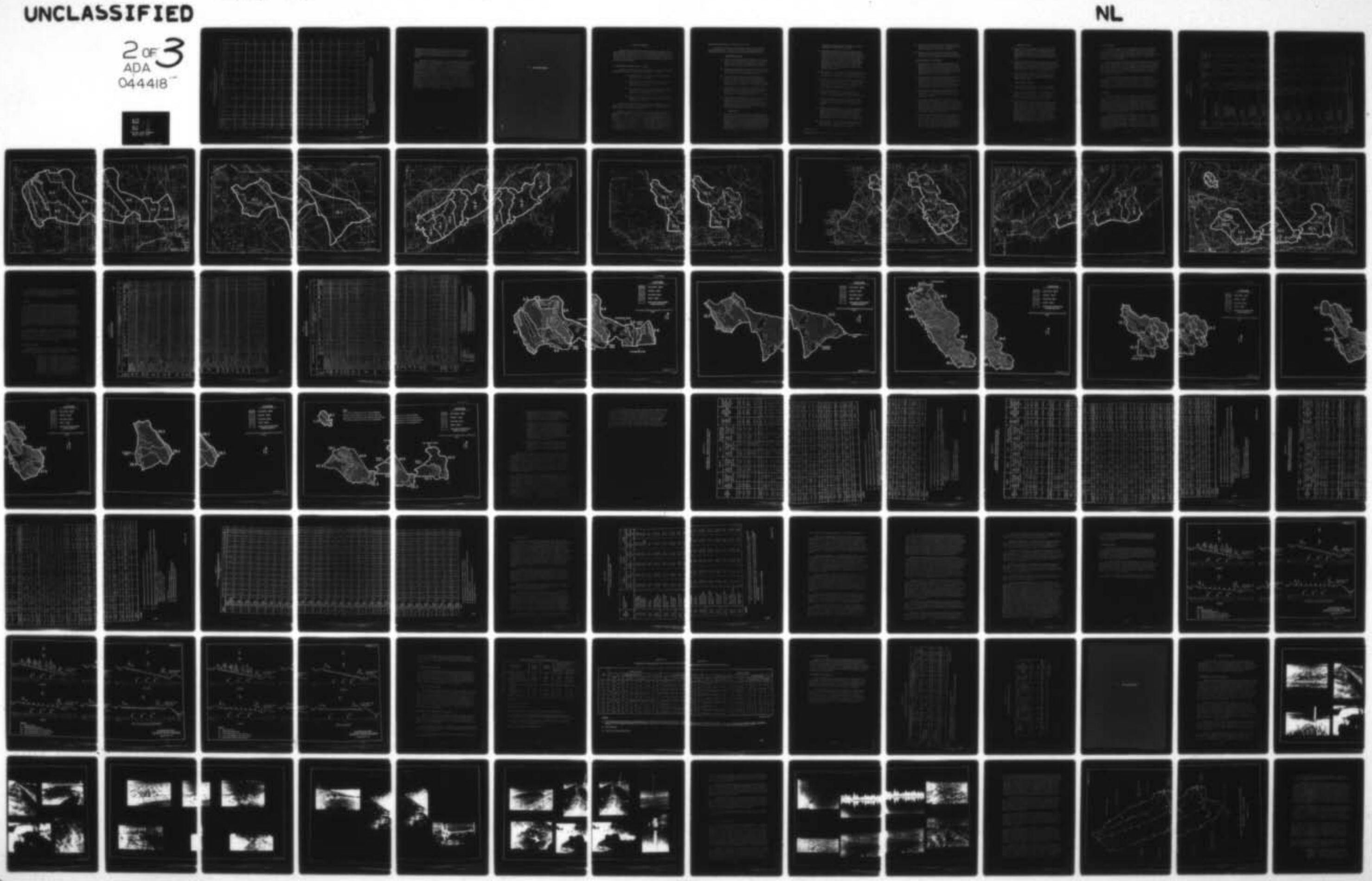

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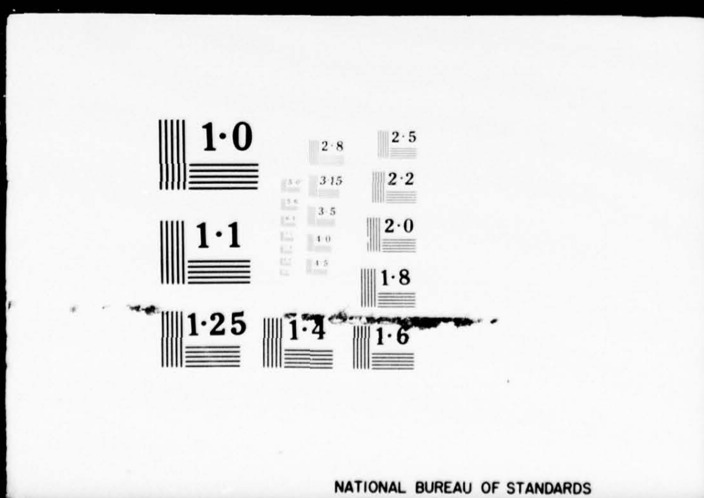

Figure II-E-1

Table II-D-3

SOIL DISTRIBUTION REPRESENTIVITY MATRIX 1/
(% OF MAXIMUM CORRELATION)

Potential Sites	SELECTED SITES								
	4	5	12	18	21	27	28	42	43
1	17	14	5	5	11	3	2	-0-	73
2	50	12	3	47	3	6	6	16	-0-
3	5	8	6	2	4	6	5	1	8
4	100	13	6	50	5	8	7	9	33
5	31	100	42	46	37	44	25	64	34
6	-0-	20	60	7	38	32	26	27	10
7	25	37	47	8	48	42	43	22	37
8	15	24	19	7	10	13	8	5	19
9	3	12	9	2	5	9	3	6	6
10	5	8	6	2	4	6	5	1	8
11	30	21	12.	3	7	9	2	5	34
12	15	41	100	17	42	57	45	32	23
13	45	21	33	55	62	39	45	28	14
14	65	30	33	74	26	38	33	41	10
15	45	2	-0-	34	3	4	4	6	-0-
16	-0-	16	8	14	10	5	4	9	10
17	87	11	5	56	5	9	8	10	40
18	59	43	16	100	25	20	20	40	14
19	20	9	13	21	61	31	68	26	-0-
20	50	4	20	51	56	28	58	22	-0-
21	18	28	23	27	100	39	79	28	14
22	58	13	19	55	20	23	23	30	1
23	64	17	6	57	19	10	10	12	11
24	56	18	4	50	24	7	7	8	14
25	-0-	1	23	1	45	25	45	11	-0-
26	10	25	28	21	64	37	69	26	5
27	29	48	69	31	56	100	65	55	17
28	27	27	35	32	80	53	100	33	13
29	3	10	19	6	40	21	50	13	3
30	-0-	2	12	1	39	12	39	7	-0-
31	-0-	-0-	10	-0-	36	10	38	5	-0-
32	57	29	13	66	11	20	20	34	12
33	40	15	28	51	68	34	64	25	10
34	5	36	10	21	26	20	7	27	14
35	20	14	19	26	69	37	76	26	5
36	3	10	52	4	40	35	40	22	-0-

18	59	43	16	100	25	20	20	40	14
19	20	9	13	21	61	31	68	26	-0-
20	50	4	20	51	56	28	58	22	-0-
21	18	28	23	27	100	39	79	28	14
22	58	13	19	55	20	23	23	30	1
23	64	17	6	57	19	10	10	12	11
24	56	18	4	50	24	7	7	8	14
25	-0-	1	23	1	45	25	45	11	-0-
26	10	25	28	21	64	37	69	26	5
27	29	48	69	31	56	100	65	55	17
28	27	27	35	32	80	53	100	33	13
29	3	10	19	6	40	21	50	13	3
30	-0-	2	12	1	39	12	39	7	-0-
31	-0-	-0-	10	-0-	36	10	38	5	-0-
32	57	29	13	66	11	20	20	34	12
33	40	15	28	51	68	34	64	25	10
34	5	36	10	21	26	20	7	27	14
35	20	14	19	26	69	37	76	26	5
36	3	10	52	4	40	35	40	22	-0-
37	3	33	58	11	67	35	55	22	20
38	-0-	16	23	6	13	5	1	5	10
39	20	39	13	15	9	6	3	22	26
40	27	39	49	13	20	16	5	15	54
41	11	3	2	-0-	-0-	1	-0-	-0-	69
42	27	50	44	42	35	56	33	100	2
43	13	21	7	10	17	4	3	-0-	100
44	20	13	6	4	9	3	2	-0-	61
45	11	3	2	-0-	-0-	1	-0-	-0-	69
46	35	44	29	23	24	40	24	35	21
47	2	2	11	3	39	12	41	7	-0-
48	63	27	4	63	4	9	9	31	3
49	-0-	6	2	3	7	4	1	-0-	5
50	11	39	45	21	11	27	9	18	22
51	18	24	30	2	2	10	5	7	18
52	25	38	45	9	10	17	6	17	32
53	24	13	6	3	7	3	2	-0-	50

NOTES:

1/ Based on the soil capability class distributions shown in Table
A value of 50% indicates that one-half of the distribution of capability classes of the potential site matches the distribution pattern of the selected site.

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desirability tabulation based on estimated soil distributions and site sizes can easily be made by assigning desirability coefficients to soil capability classes and applying the relative site size and capability class coefficients to the distributions shown in Table II-D-2.

The relative desirability (based on soil associations) and suitability of a potential site for wastewater application can be estimated from the data presented in these two tables. Table II-D-2 can be utilized in determining potential site suitability based on soil capability class distributions. For example, if it is determined that a combination of 70 percent Class I soils and 30 percent Class II soils in a site is advantageous for development, a review of Table II-D-2 indicates that Site 38 represents that distribution. Table II-D-3 correlates soil distribution patterns of sites and can be utilized to determine potential site suitability based on soil representivity. For example, if it is determined that the soil distribution pattern of Site 43 is desirable, Table II-D-3 shows that Sites 1, 41, and 45 most nearly represent that soil capability class distribution pattern. As previously mentioned, site sizes should be incorporated into representivity considerations to accurately determine site desirabilities and development potentials.

E. SITE EVALUATION

E. SITE EVALUATION

The nine sites selected for more detailed study provide a range of development possibilities which include traditional irrigated agriculture, improved wildlife habitats, forest plantations and rapid infiltration areas for maximum wastewater disposal. Each development possibility as well as combinations thereof has associated economic, environmental and public health impacts.

1 - Site Evaluation Objectives and Criteria

The primary objectives to be considered in the evaluation of the development potential of the identified wastewater sites are:

a) Provide maximum use of the soil mantle as a treatment system for wastewater,

b) Create maximum utilization of the treated drainage water which can be recovered or can otherwise become available for reuse,

c) Provide opportunities for economic returns to accrue to the land through agricultural practices that are consistent with objectives a and b, and

d) Provide opportunities for environmental enhancement through land use practices that are consistent with objectives a, b and c.

The preceding objectives do not establish a complete guide for site evaluation until they are supplemented with more specific criteria which describe the method of evaluation.

Although wastewater treatment and reuse systems have been installed and operated successfully at various locations throughout the world and in California, few of these systems have been designed with fully comprehensive water resources and related land resource management in mind. Specific criteria for comparative evaluation of potential sites for wastewater treatment through land application are not available. The recommended evaluation criteria submitted by the Special Technical Consultants are contained in Volume IV of this report. Many of the criteria for individual areas of concern are interrelated as well as complementary to each other. It is important that these interrelationships are

recognized and reflected in the evaluation of sites.

Using the Consultants' recommended criteria and the primary evaluation objectives, the following specific criteria were selected for use in the evaluation of potential wastewater application sites.

Topographic Criteria

1) The net site area (that portion of the total site which can accept wastewater) must include at least 5,000 acres. This criterion is derived from a judgement that smaller sites will be uneconomical to develop.

2) Land units within potential sites at elevations greater than 100 feet above the terminus of transport facility may be excluded from the effective site area.

3) Land units within potential sites with slopes in excess of 30% will be excluded from the effective site area. Water management and land treatment measures should be included in the site development plan for land units which exhibit high erosion hazards.

4) Suitable locations should be available either within the potential site or along the wastewater transport facility for storage of wastewater during seasonal periods when wastewater application cannot be made.

5) Suitable locations should be available either within the potential site or along the wastewater transport facility for installation of pre-treatment facilities where such pre-treatment will be required to satisfy environmental quality, agricultural land use, water quality or public health criteria.

Soil Criteria

1) The annual infiltration capacities of potential sites should be considered using the soil types which have been identified in the site area as indicated in Section D, the parameters used to describe the characteristics of these soil types as discussed in Section C, and the practical experience of irrigation and wastewater disposal agencies which operate within sites with similar characteristics. Land units with soil profiles not

amenable to effective drainage systems should be excluded from the effective site area.

2) The depth and character of the soil profile should be appraised throughout potential sites to assure that the percolation capacity of the area is generally sufficient to avoid waterlogging and suffocation of planned crops and ground covers. The occurrance of hardpan strate or bedrock should be identified. The drainage characteristics of these areas should be reviewed to determine the types of drainage systems which may be installed to maintain a permanent ground cover.

3) The frequency and duration of resting periods required to maintain infiltration capacity should be estimated on the basis of information contained in the literature.

4) The capacity of individual soils to assimilate organic materials should be estimated to assure that wastewater treatment criteria has been satisfied. Land units with soils that cannot meet this criteria should be excluded from the effective site area.

5) The ability of individual soils to adsorb toxic materials, heavy metals, radiologic materials, bacteria, viruses and pathogens should be appraised.

6) Land units should be appraised in relation to soil structure and the quality of the wastewaters to be applied to assure that infiltration capacity is maintained.

7) Irrigated agricultural land use should be considered for land units that have been classified Class III or higher. Conversion of agricultural land use from non-irrigated to irrigated and from low-value to high-value crops will be sought on land units that have been classified as either Class I or Class II. 1/

8) The suitability of soils within site areas should be generally appraised in terms of their ability to support non-agricultural type ground covers.

1/ See Table II-C-2 for description of Soil Capability Classes

9) Erosion hazards should be assessed using general soil characteristics, topography, vegetal cover and required wastewater application schedules.

10) Land units which pose a high risk of land slides under saturated conditions as a result of slope and soils should be excluded from the effective site area.

Crop and Ground Cover Criteria

1) The suitability of specific agricultural crops and existing natural ground covers with respect to the quality of the wastewaters which are to be applied should be determined through interpretation of basic criteria developed by the U. S. Department of Agriculture and the University of California.

2) The potential for intensification of agricultural land use and conversion to higher-value crops within potential sites should be determined in relationship to the soil class, the existing crop pattern and water supply, the quantity and quality of the wastewater and general agricultural economic factors.

3) An assessment should be made of the replacement of existing crops within the potential site with vegetative covers that are better suited for water application programs.

4) In land units within potential sites where native vegetation will be retained as part of the wastewater application area, long-term modification of this vegetative pattern should be estimated considering the present and possible diversity of species in the area, general aesthetic appeal and the ability of the unit to support a more diversified flora.

5) An annual water and salt balance should be prepared for each site showing the estimated crop water requirement, farm delivery requirement and the site delivery requirement. The water balance will be based on the crops and ground covers recommended, generalized evapo-transpiration rates and rainfall patterns and typical seepage and operational losses.

Geologic Criteria

1) Land units within potential sites with ground water aquifers which are presently or potentially usable for irrigation purposes should be excluded if the percolation of wastewater to the aquifer will cause significant deterioration of the quality of the ground water.

2) If the estimated rate of percolation into ground water aquifers from land units within potential sites exceeds the transmissibility of these aquifers, drainage systems discharging to surface waters or to recycling sumps should be included in the site development plan.

3) Land units within potential sites with known fault zones which will allow the applied wastewater to be transmitted directly into ground water aquifers should be excluded.

Water Quality Criteria

1) All wastewaters shall have had at least secondary levels of pre-treatment prior to land application.

2) Wastewaters and percolated wastewaters which are to be discharged into surface and ground waters shall meet waste discharge standards of the State of California Water Resources Control Board.

3) The present and projected quality of existing surface and ground water supplied available to a potential site should be assessed to determine if the wastewater supply can serve as an adequate replacement source. Land units within potential sites with ground water aquifers presently or potentially used for drinking water supply purposes should be excluded from the effective site area if the chemical and bacteriological quality of the percolated wastewater would cause the reaulting ground water to exceed U. S. Public Health Service standards.

2 - Site Sub-Areas

In accordance with the criteria established for site evaluation, each of the nine selected sites was divided into sub-areas which can be evaluated as separate potential projects. These divisions were dictated primarily by the natural drainage patterns (i.e., tributary watersheds) and to a lesser extent by existing land uses. Table II-E-1 gives the sub-areas identified.

The boundaries of each of the nine selected sites shown in Figure II-E-1 have been outlined on a montage of 1:24,000 scale U. S. Geological Service topographic maps. The original site boundaries established in the site identification phase were modified on the basis of the additional topographical detail available from these montages. Hence, the areas shown in Table II-E-1 may not correspond exactly with the gross areas shown in Table II-D-1.

Some sub-areas were combined in the evaluation process (Sub-Areas 18.4, 5 and 6; 27.3, 4 and 5; and 28.2 and 3) because they did not include a major watershed of 5,000 acres or greater which could be considered as a project. These sub-areas can, however, be considered as potential wastewater application areas and have been evaluated compositely for soil distributions and recommended land uses.

3 - Climate

The nine selected sites are situated in climatic regimes ranging from arid to coastal. Annual precipitation varies from less than 10 inches to about 60 inches and average July temperatures vary from 60° to 80°F. Snowfall is rare in any of the sites and is usually confined to elevations above 1,000 feet. Killing frosts in late Spring are a hazard to orchards, vines and other early crops. Many of these crops are protected from frost by sprinklers, wind machines and smudge pots. High winds from thunderstorms, tornadoes, hurricanes or typhoons are not a serious problem in any of the sites.

The data given in the last three columns of Table II-E-1 are good indicators of the general climatic conditions relative to vegetation. It can be seen that even though temperature, humidity and rainfall vary significantly between sites, the variation in annual water requirements of plants not supplied by precipitation is much less. This is due to the poor distribution of precipitation throughout the year (approximately 80% of the annual precipitation occurs in the five-month period of November through March).

Table II-E-1

SITE SUB-AREA DATA

Site Sub-Area No.	Distinguishing Feature	Gross Area (1000 acres)	Potential Evapotranspiration 1/ (feet)	Mean Annual Precipitation 2/ (feet)	Annual Vegetation Requirement 3/ (feet)
4.1	Montezuma Slough	5.6	3.8	1.4	3.1
4.2	Grizzly Island	6.6	3.8	1.4	3.1
Total		12.2	---	---	---
5.1	Capay Valley	67.1	3.9	1.8	3.0
5.2	Hungry Hollow	44.7	3.4	1.5	2.6
5.3	Dunnigan Hills	98.8	3.7	1.5	2.8
5.4	Yolo Plains	86.3	4.1	1.3	3.3
5.5	Yolo Bypass	22.4	4.1	1.3	3.3
5.6	Sacramento	33.3	4.1	1.4	3.3
Total		352.6	---	---	---
12.1	Pinoche	87.2	4.4	0.9	3.8
12.2	Dos Palos	143.9	4.4	0.7	3.9
Total		231.1	---	---	---
18.1	Sebastopol	23.4	3.4	2.8	2.3
18.2	Salmon Creek	20.0	3.4	3.7	2.2
18.3	Lagunitas Creek	35.4	3.4	2.9	2.3
18.4,5,6	Not specific	117.4	3.4	3.1	2.3
Total		196.2	---	---	---
21.1	Alexander Valley	42.6	3.8	4.3	2.4
21.2	Knight's Valley	60.4	3.8	4.8	2.3
21.3	Windsor	22.0	3.8	3.0	2.6
[illegible]		125.0	---	---	---

12.1	Pinoche	87.2	4.4	0.9	3.8
12.2	Dos Palos	143.9	4.4	0.7	3.9
Total		231.1	---	---	---
18.1	Sebastopol	23.4	3.4	2.8	2.3
18.2	Salmon Creek	20.0	3.4	3.7	2.2
18.3	Lagunitas Creek	35.4	3.4	2.9	2.3
18.4,5,6	Not specific	117.4	3.4	3.1	2.3
Total		196.2	---	---	---
21.1	Alexander Valley	42.6	3.8	4.3	2.4
21.2	Knight's Valley	60.4	3.8	4.8	2.3
21.3	Windsor	22.0	3.8	3.0	2.6
Total		125.0	---	---	---
27.1	Gabilan Creek	23.3	3.8	1.6	2.9
27.2	Quail Creek	47.7	3.8	1.1	3.1
27.3,4,5	Not specific	70.4	3.8	1.4	3.0
Total		141.4	---	---	---
28.1	Pescadero Creek	38.5	3.2	3.2	2.1
28.2,3	Not specific	88.4	3.2	3.2	2.1
Total		126.9	---	---	---
42.1	Deer Valley	2.0	3.8	0.9	3.2
42.2	Marsh Creek	27.1	3.8	1.5	3.1
42.3	Clifton Court Forebay	13.0	3.8	1.1	3.2
42.4	Not specific	65.5	3.8	1.2	3.2
Total		107.6	---	---	---
43.1	Roberts Island	25.8	3.7	0.9	3.2
43.2	Union Island	36.2	3.7	1.1	3.1
Total		62.0	---	---	---
Grand Total		1355.0			

1/ Estimated from pan evaporation measurements (see Table II-E-4)
2/ Interpolated from iso-hyetal maps
3/ Portion of potential evapotranspiration not supplied by precipitation (See Table II-E-6)

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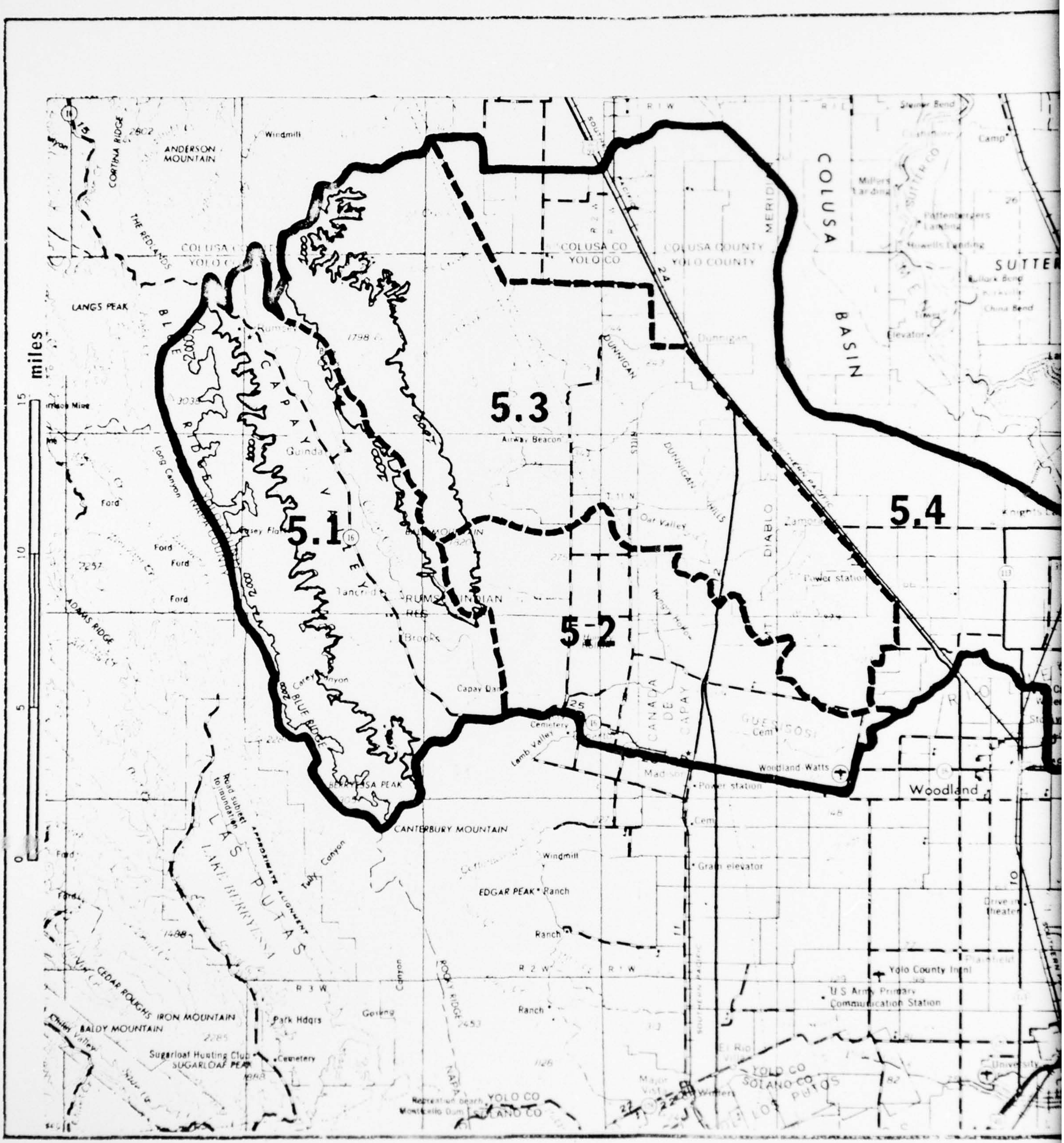
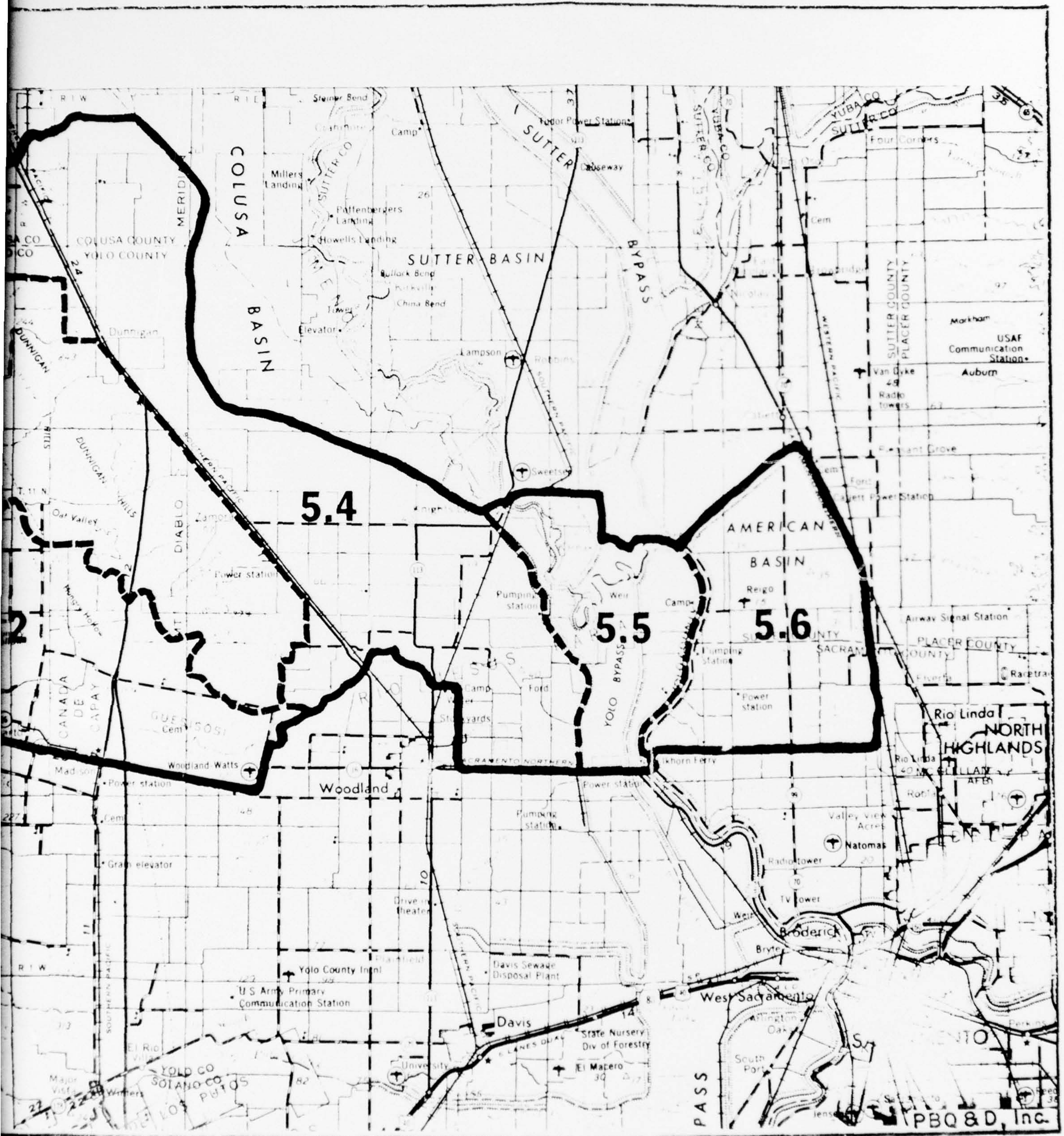
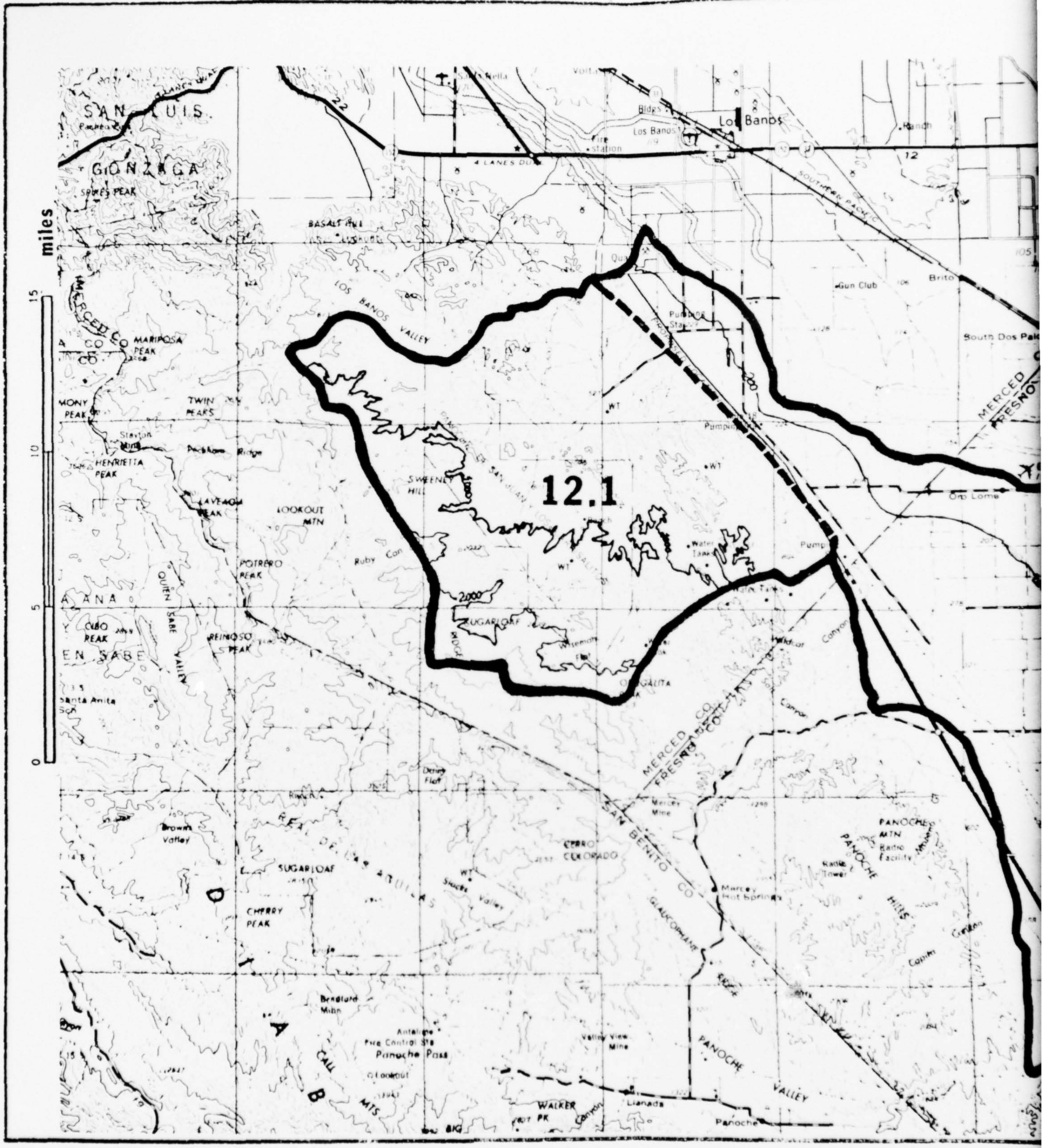
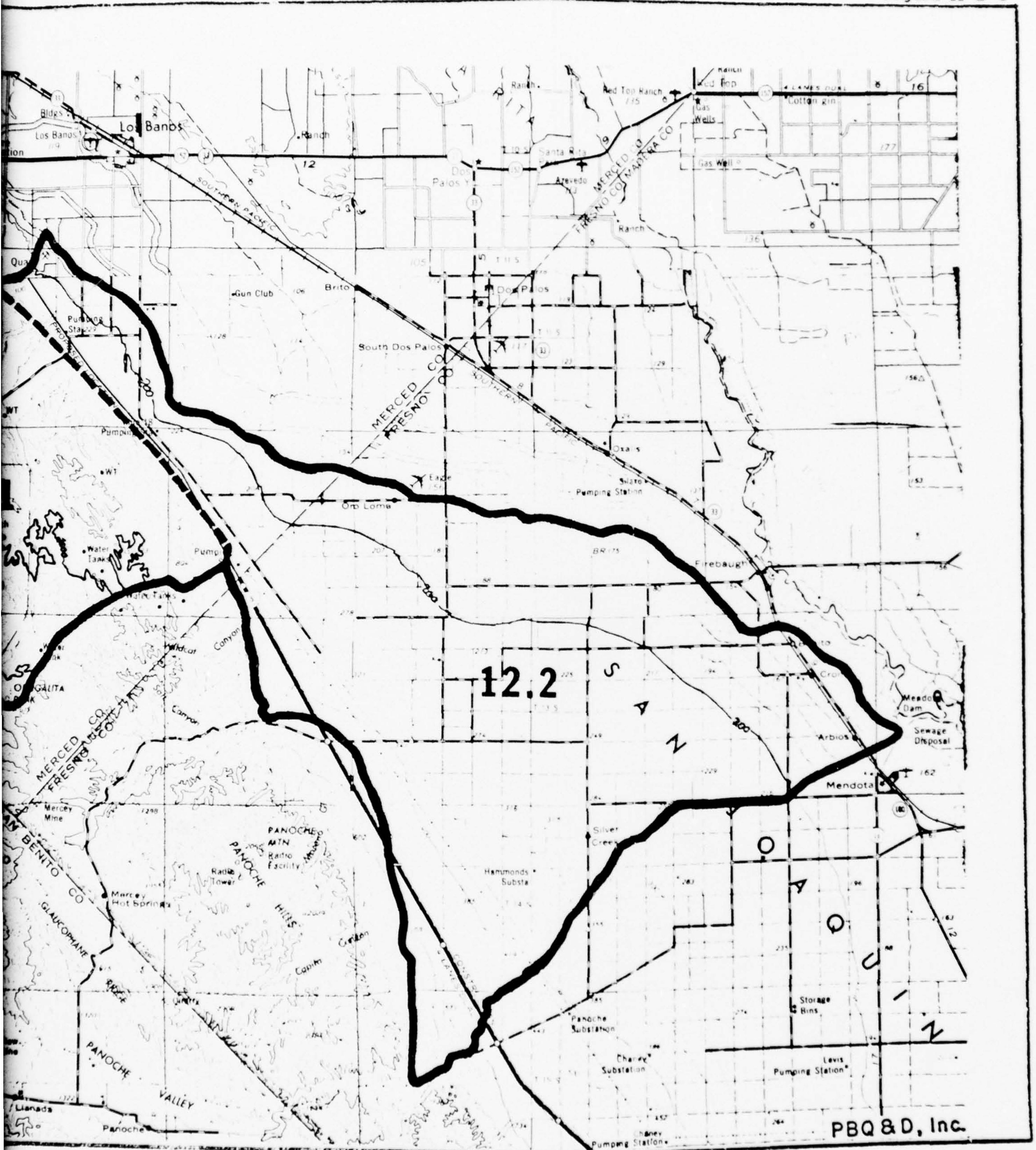


5.1
5.2
5.3
5.4
miles
0
5
10
15
ANDERSON MOUNTAIN
CORTINA RIDGE
COLUSA COUNTY
YOLO COUNTY
COLUSA BASIN
SUTTER
LANGS PEAK
CAPAY VALLEY
Guinda
Rumsey
Brooks
Capay Dam
Airway Beacon
Dunnigan
Zamora
Oat Valley
Power station
DUNNIGAN HILLS
CANADA DE CAPAY
Woodland
Woodland Watts
Madison
BLUE RIDGE
CANTERBURY MOUNTAIN
EDGAR PEAK
LAS PUTAS
LAKE BERRYESSA
Grain elevator
Yolo County Infml
U S Army Primary Communication Station
CEDAR ROUGHS
IRON MOUNTAIN
BALDY MOUNTAIN
SUGARLOAF PEAK
Park Hdqrs
Winters
YOLO CO
SOLANO CO
Windmill
Ranch
Cemetery
Lamb Valley
Long Canyon
ADAMS RIDGE
Ford


5.4
5.5
5.6
COLUSA BASIN
SUTTER BASIN
AMERICAN BASIN
SUTTER BYPASS
YOLO BYPASS
COLUSA COUNTY
YOLO COUNTY
SUTTER COUNTY
PLACER COUNTY
Woodland
Davis
West Sacramento
Broderick
Rio Linda
NORTH HIGHLANDS
PBQ&D, Inc.



miles
0
5
10
15
12.1
Los Banos
SAN LUIS
GONZAGA
LOS BANOS VALLEY
MERCED CO
FRESNO CO
SAN BENITO CO
MARIPOSA PEAK
TWIN PEAKS
HENRIETTA PEAK
LOOKOUT MTN
POTRERO PEAK
SWEENEY HILL
SUGARLOAF
CERRO COLORADO
CHERRY PEAK
PANOCHE MTN
PANOCHE HILLS
PANOCHE VALLEY
Panoche Pass
Panoche
Llanada
WALKER PK
Mercey Hot Springs
Gun Club
South Dos Palos
Oro Loma
SOUTHERN PACIFIC



Los Banos
12.2
SAN JOAQUIN
Dos Palos
South Dos Palos
Firebaugh
Mendota
Brito
Gun Club
Oro Loma
Panoche Substation
Levis Pumping Station
Storage Bins
Silver Creek
Hammonds Substa
MERCED CO
FRESNO CO
SAN BENITO CO
PANOCHE VALLEY
PANOCHE HILLS
PANOCHE MTN Radio Facility
Mercey Hot Springs
Sewage Disposal
Arbios
Chaney Pumping Station
PBQ & D, Inc.

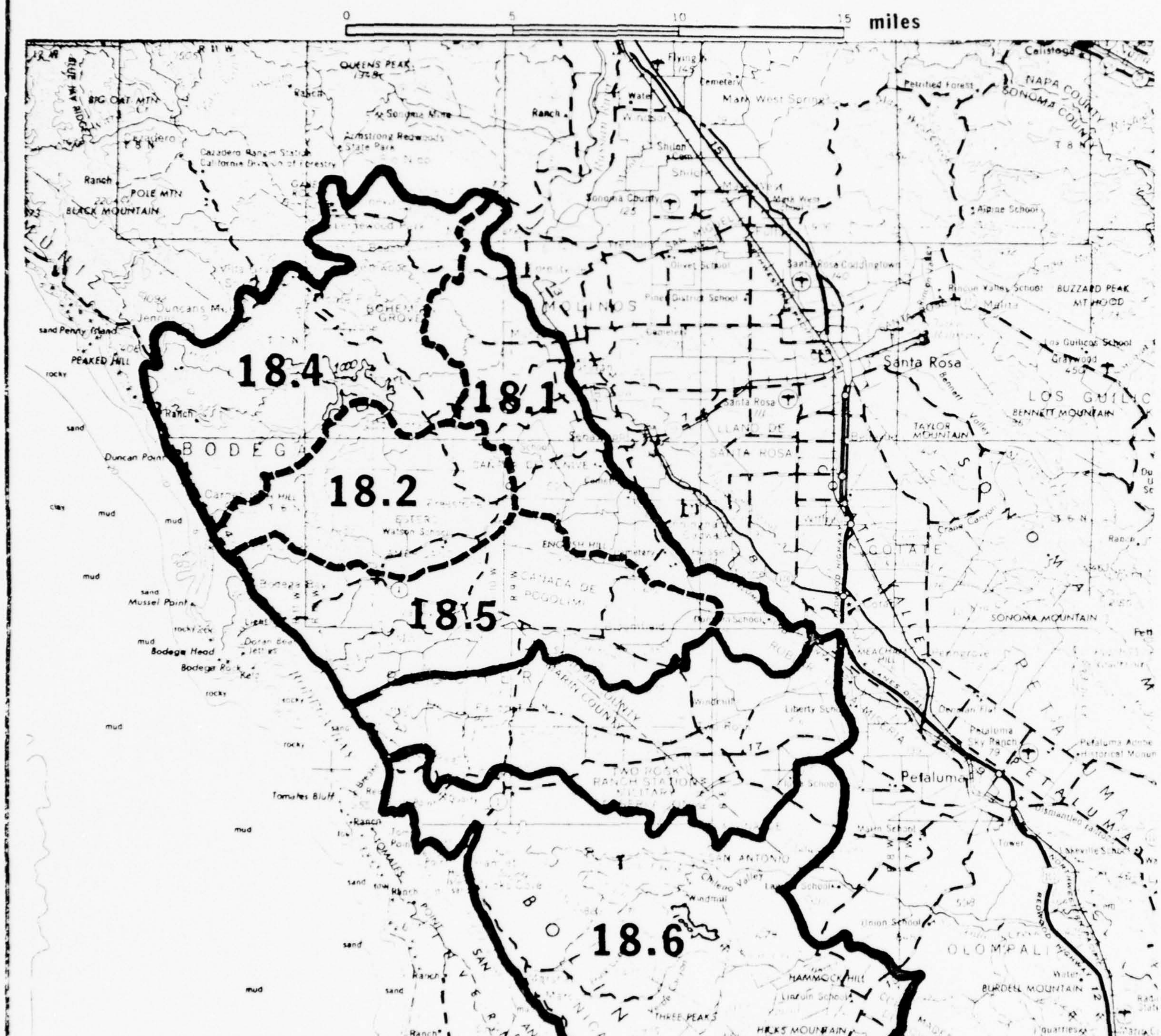
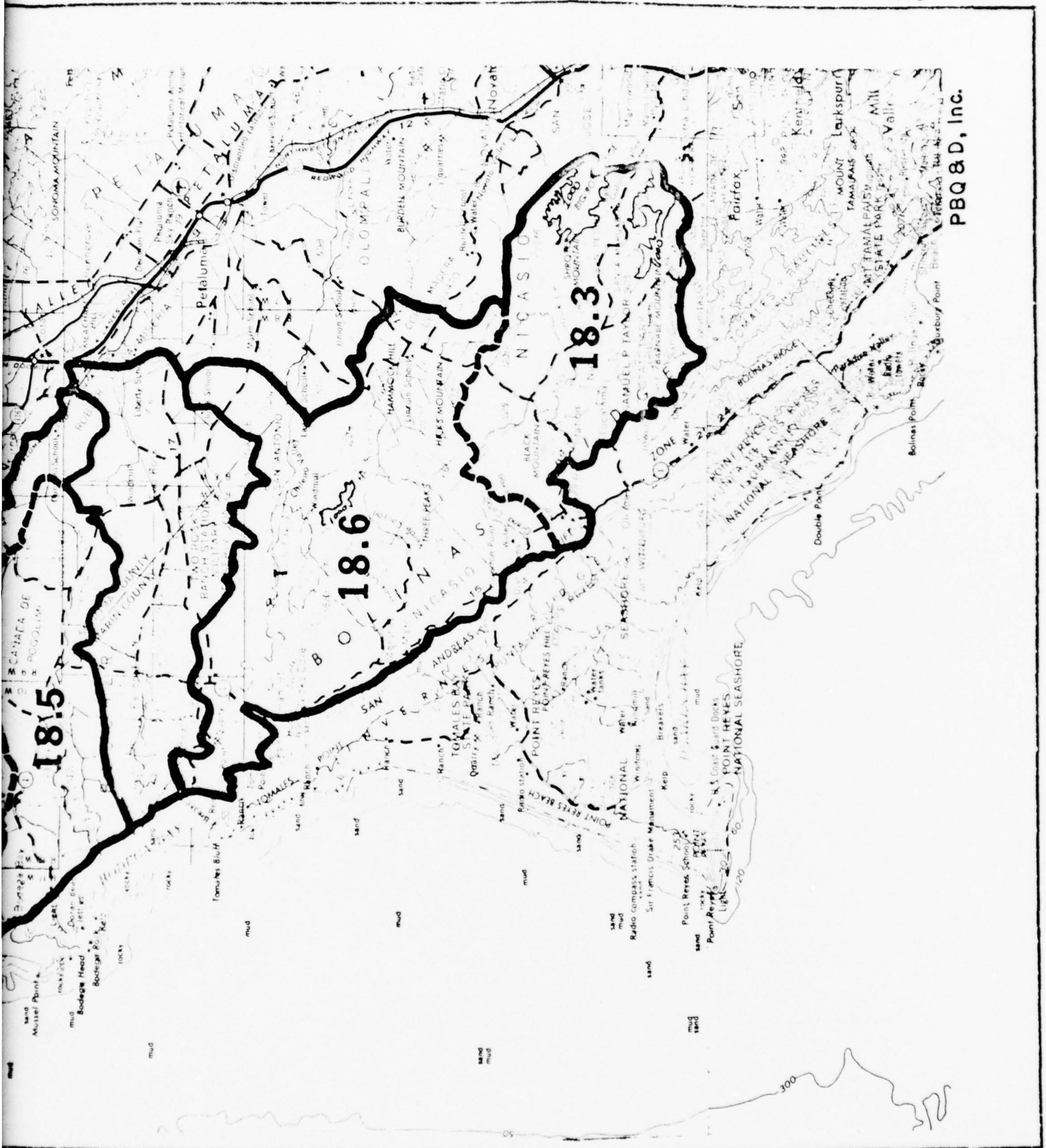
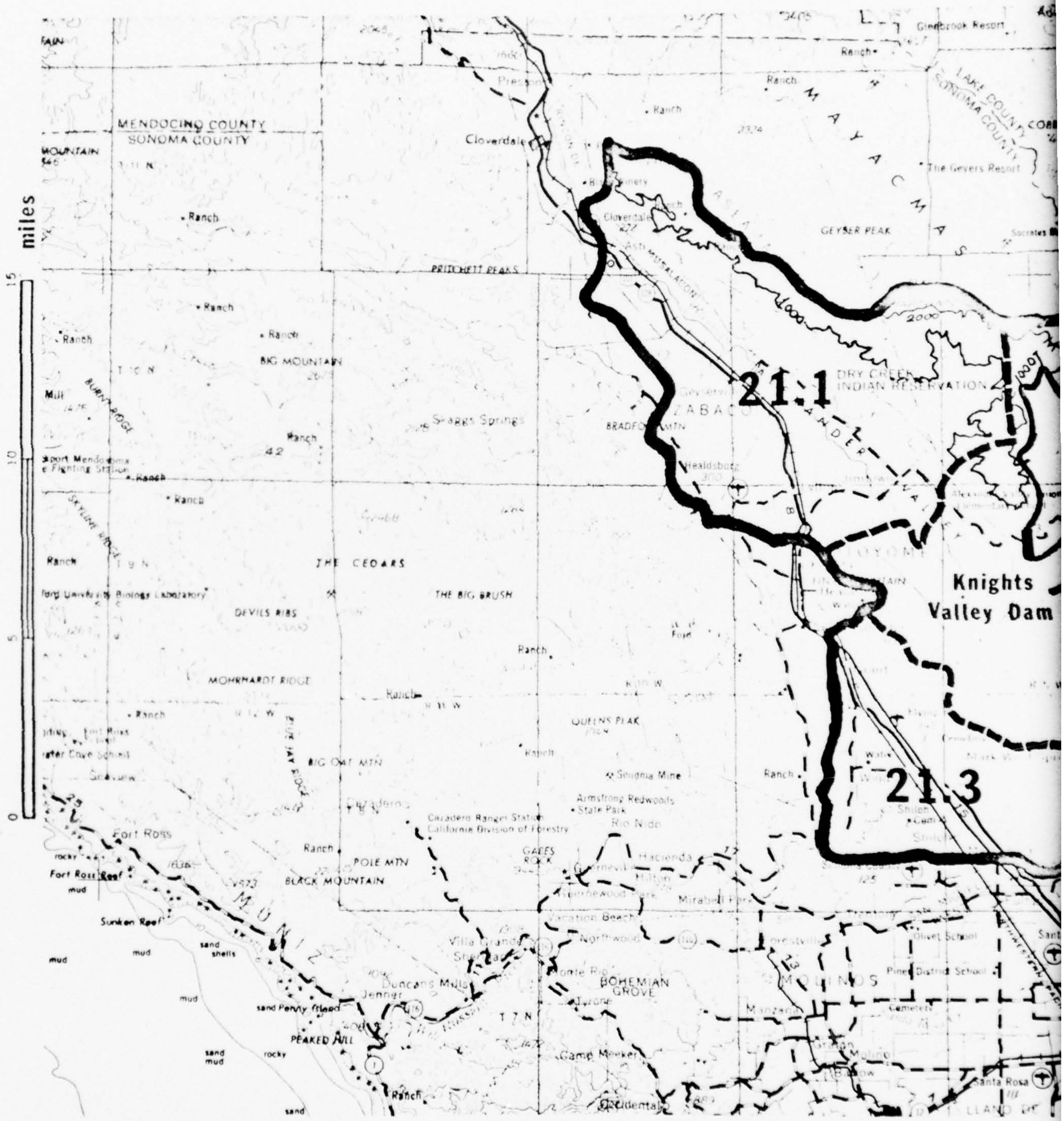
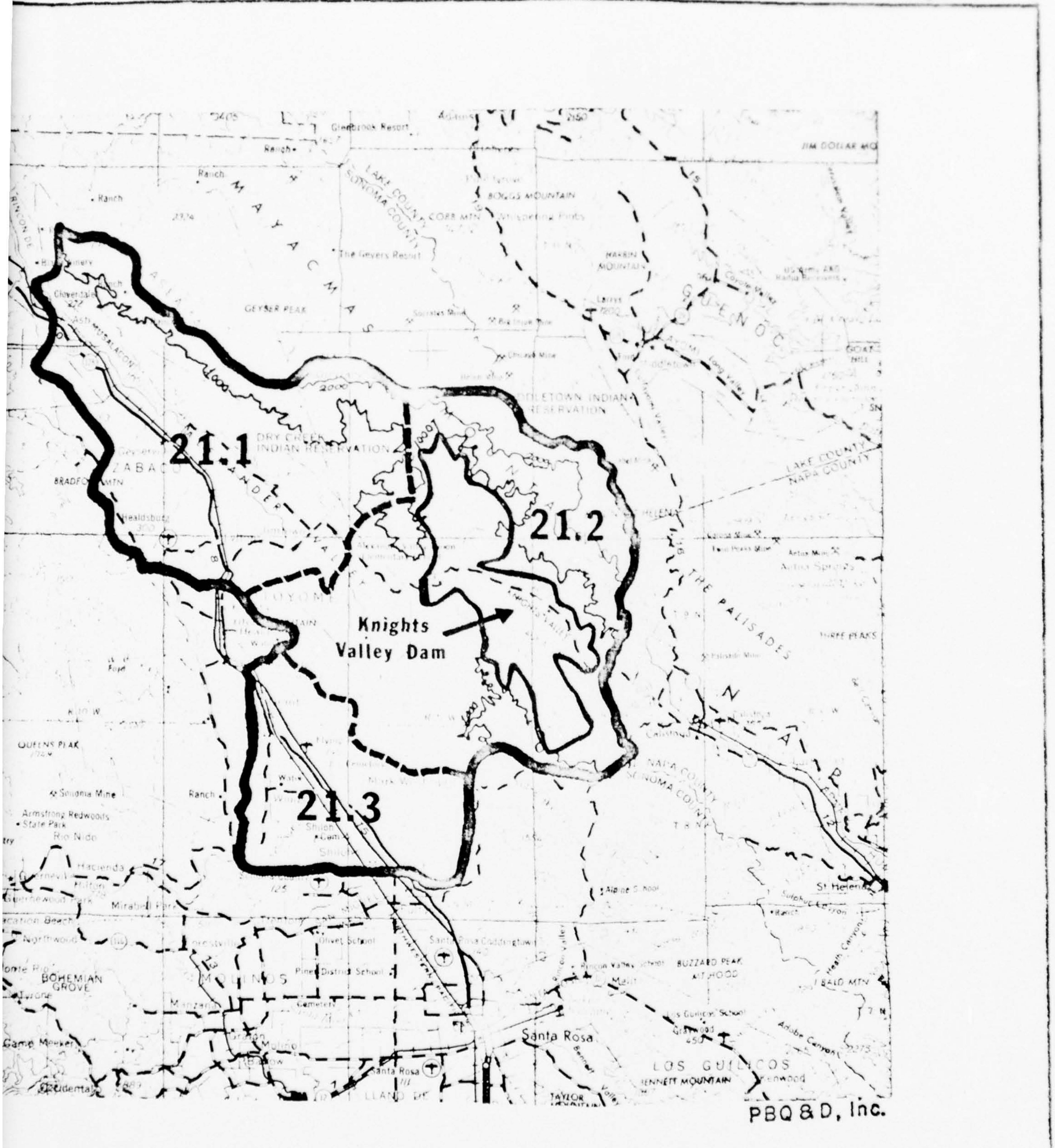
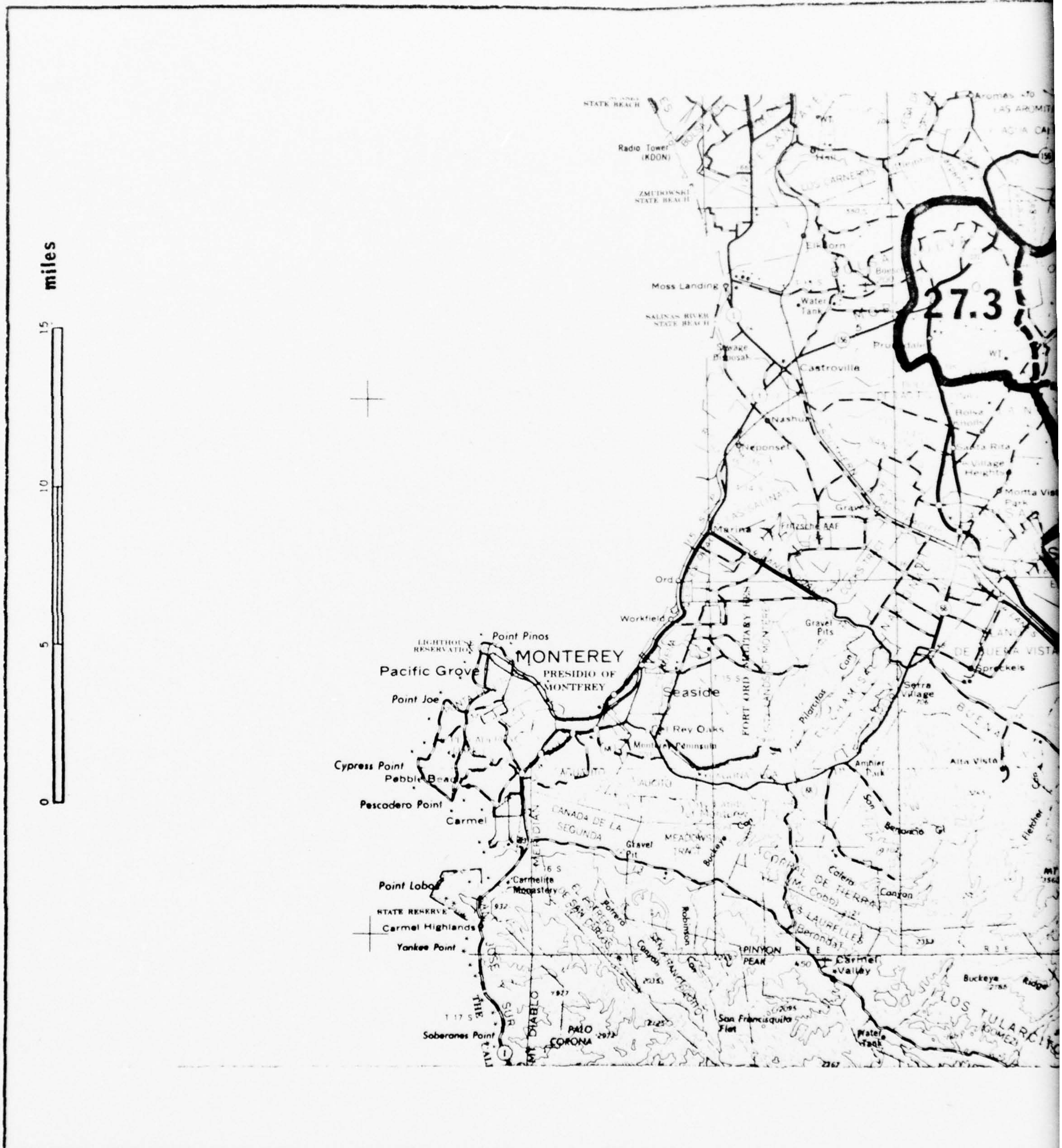

0
5
10
15
miles
18.1
18.2
18.4
18.5
18.6
Santa Rosa
Petaluma
Calistoga
NAPA COUNTY
SONOMA COUNTY
LOS GUILICOS
BENNETT MOUNTAIN
TAYLOR MOUNTAIN
SONOMA MOUNTAIN
BODEGA
MOLINOS
LLANO DE SANTA ROSA
COTATE
CANADA DE POGOLIMI
OLOMPALI
HAMMOCK HILL
HICKS MOUNTAIN
THREE PEAKS
BURDELL MOUNTAIN
SAN ANTONIO
TOMALES BAY STATE PARK
QUEENS PEAK
BIG OAT MTN
POLE MTN
BLACK MOUNTAIN
PEAKED HILL
Duncan Point
Mussel Point
Bodega Head
Tomales Bluff
Novato

Figure II-E-1


18.3
18.6
18.5
PBQ&D, Inc.
POINT REYES NATIONAL SEASHORE
BOLINAS
NICASIO
PETALUMA
OLOMPALI
Fairfax
Larkspur
MOUNT TAMALPAIS STATE PARK
Petaluma
Bolinas Point
Double Point
Point Reyes Light
Bodega Head
Tomales Bluff
POINT REYES BEACH
TOMALES BAY STATE PARK
SAN ANDREAS
BLACK MOUNTAIN
HICKS MOUNTAIN
BURDELL MOUNTAIN
SONOMA MOUNTAIN
BOLINAS RIDGE

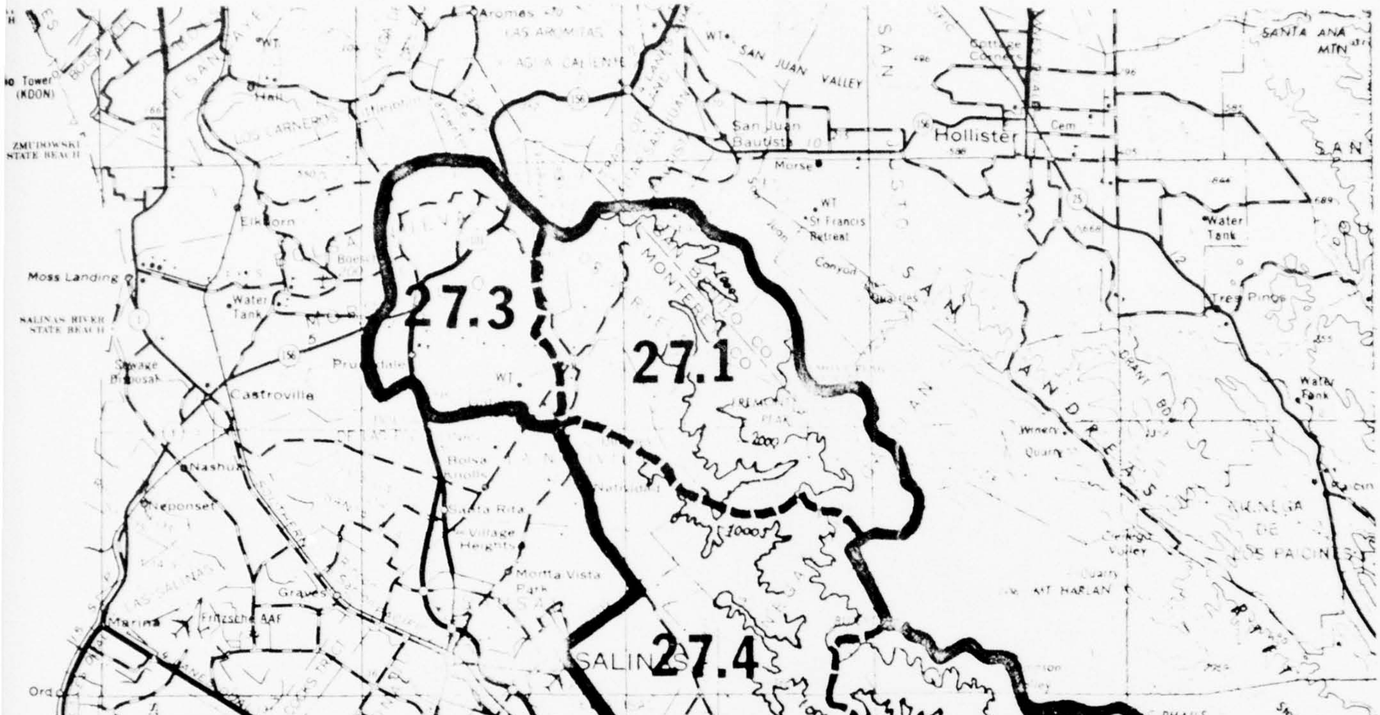

miles
0
5
10
15
MENDOCINO COUNTY
SONOMA COUNTY
LAKE COUNTY
SONOMA COUNTY
Cloverdale
Preston
Glenbrook Resort
The Geysers Resort
GEYSER PEAK
M A Y A C M A S
PRITCHETT PEAKS
BIG MOUNTAIN
21.1
DRY CREEK INDIAN RESERVATION
Geyserville
Healdsburg
Skaggs Springs
Knights
Valley Dam
THE CEDARS
THE BIG BRUSH
DEVILS RIBS
MOHRHARDT RIDGE
QUEENS PEAK
21.3
Armstrong Redwoods State Park
Rio Nido
Cazadero
Cazadero Ranger Station California Division of Forestry
POLE MTN
BLACK MOUNTAIN
Fort Ross
Fort Ross Reef
Sunken Reef
Jenner
Duncans Mills
Monte Rio
BOHEMIAN GROVE
Guerneville
Hacienda
Mirabel Park
Vacation Beach
Northwood
Forestville
Camp Meeker
Occidental
PEAKED HILL
Santa Rosa
Olivet School
Piner District School
Ranch
mud
sand
rocky


21.1
21.2
21.3
Knights Valley Dam
DRY CREEK INDIAN RESERVATION
MIDDLETOWN INDIAN RESERVATION
BOGGS MOUNTAIN
The Geysers Resort
GEYSER PEAK
Cloverdale
Healdsburg
LAKE COUNTY
SONOMA COUNTY
NAPA COUNTY
THE PALISADES
Calistoga
St Helena
Santa Rosa
LOS GUILICOS
BOHEMIAN GROVE
Armstrong Redwoods State Park
Rio Nido
Mirabel Park
Occidental
BUZZARD PEAK
QUEENS PEAK
Forestville
Shiloh
PBQ&D, Inc.

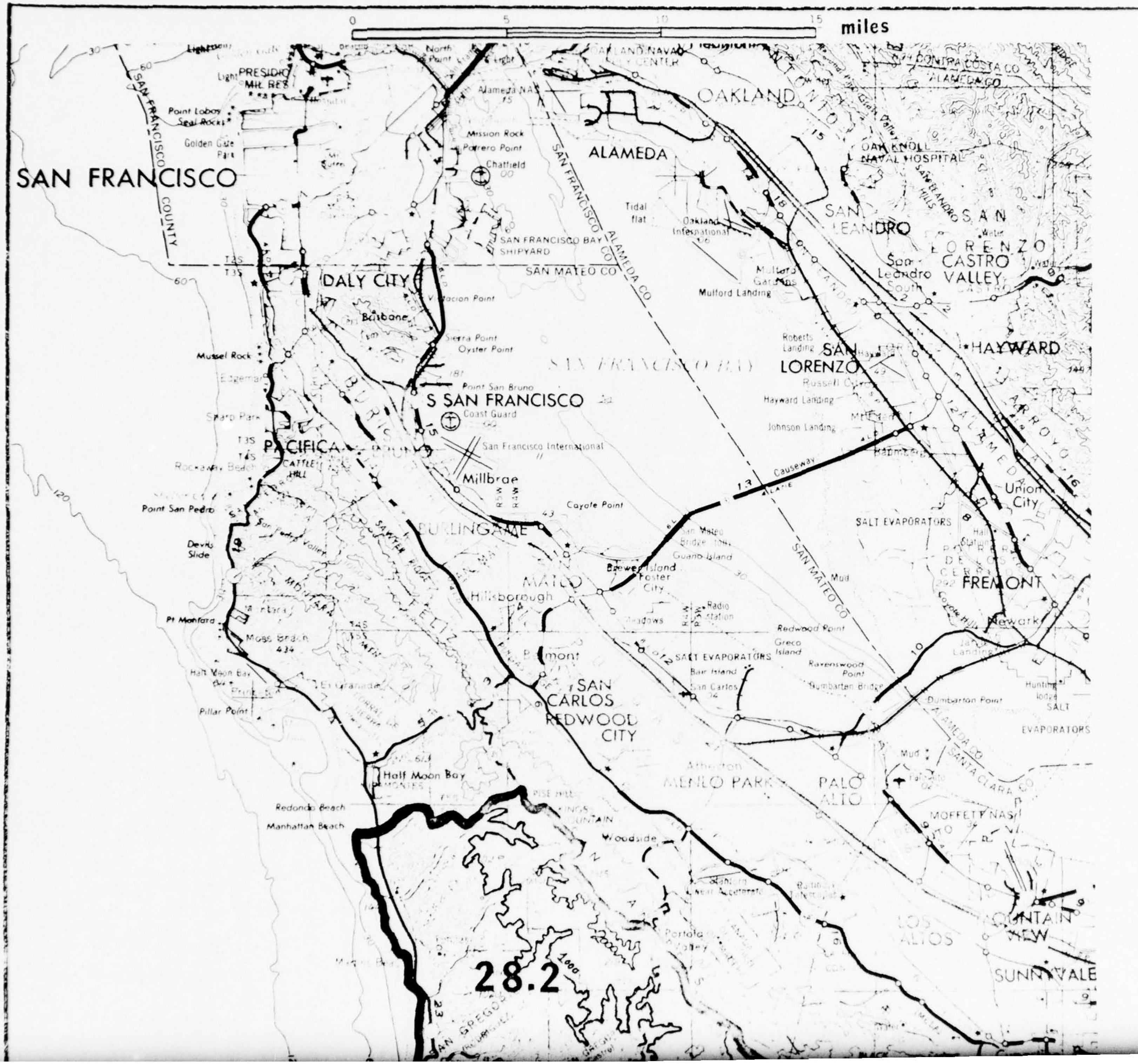


miles
0
5
10
15
27.3
STATE BEACH
Radio Tower (KDON)
ZMUDOWSKI STATE BEACH
Moss Landing
SALINAS RIVER STATE BEACH
Elkhorn
Castroville
Nashua
Neponset
Graves
Marina
Fritzsche AAF
Ord
Workfield
Point Pinos
LIGHTHOUSE RESERVATION
MONTEREY
PRESIDIO OF MONTEREY
Pacific Grove
Point Joe
Seaside
Del Rey Oaks
Monterey Peninsula
FORT ORD MILITARY RES
Cypress Point
Pebble Beach
Pescadero Point
Carmel
CANADA DE LA SEGUNDA
Gravel Pit
MEADOWS TRACT
Point Lobos
STATE RESERVE
Carmelita Monastery
Carmel Highlands
Yankee Point
Soberanes Point
PALO CORONA
San Francisquito Flat
PINYON PEAK
Carmel Valley
Spreckels
Alta Vista
Buckeye
LOS TULARCITOS
Castroville
Bolsa Knolls
Santa Rita
Village Heights
Monta Vista Park
Gravel Pits
Corral de Tierra
Canyon
Robinson

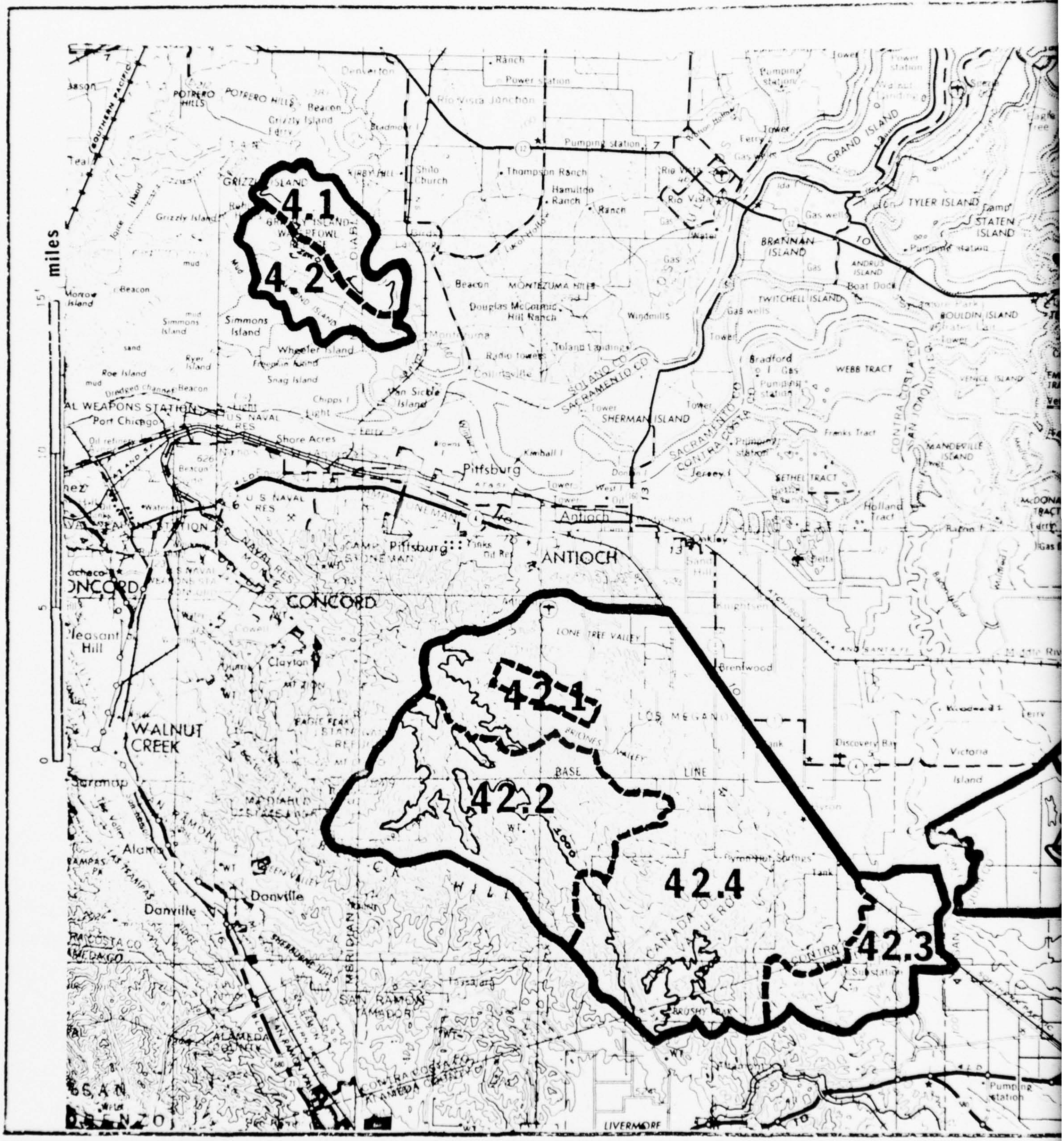
Figure II-E-1



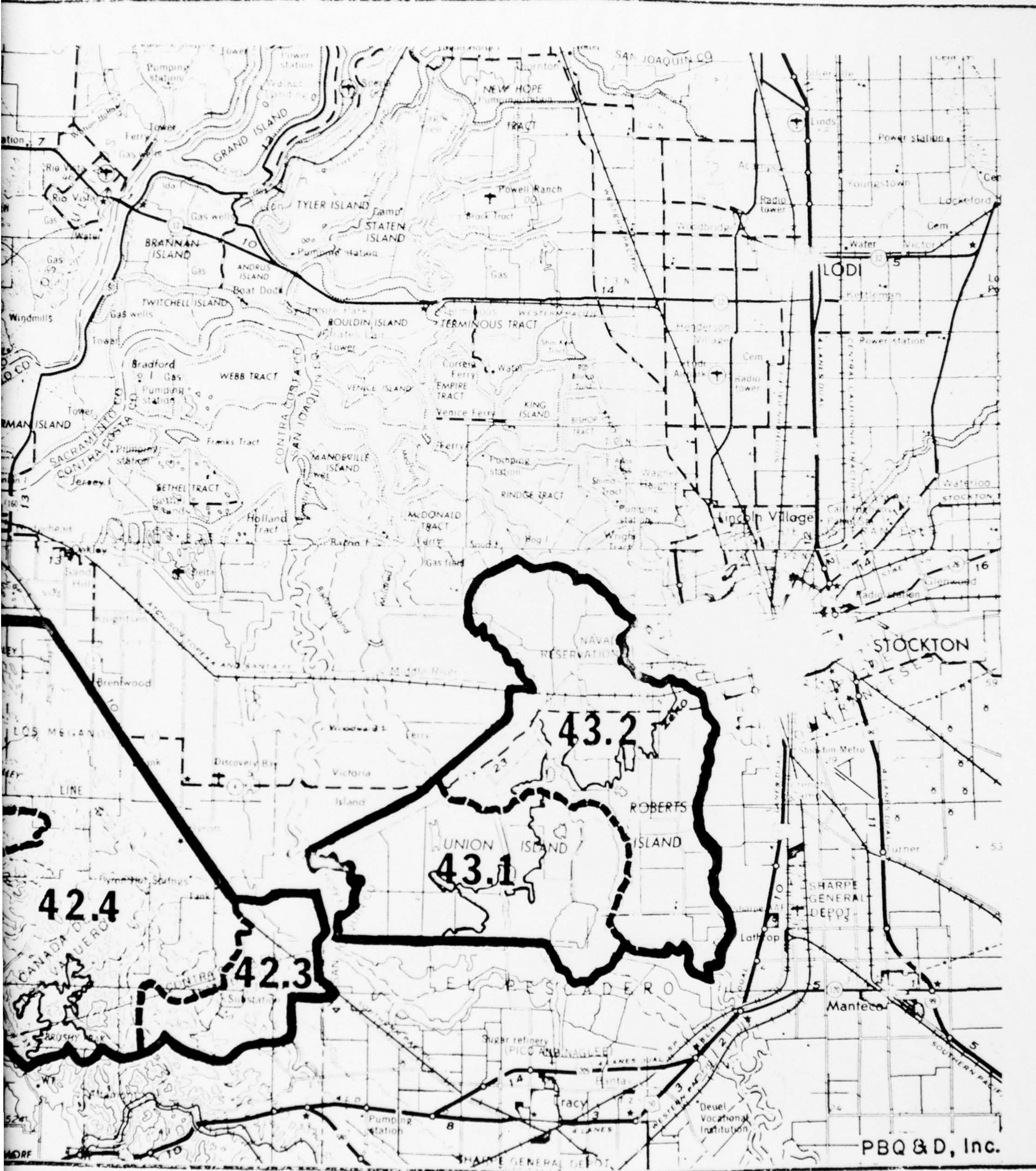
PBQ&D, Inc.


0
5
10
15
miles
SAN FRANCISCO
SAN FRANCISCO COUNTY
Point Lobos
Seal Rocks
Golden Gate Park
PRESIDIO MIL RES
North Point
Alameda NAS
Mission Rock
Potrero Point
Chatfield
SAN FRANCISCO BAY SHIPYARD
SAN MATEO CO
SAN FRANCISCO BAY CO
ALAMEDA CO
OAKLAND NAVAL SUPPLY CENTER
OAKLAND
ALAMEDA
Tidal flat
Oakland International
OAK KNOLL NAVAL HOSPITAL
SAN LEANDRO HILLS
CONTRA COSTA CO
ALAMEDA CO
SAN LEANDRO
SAN LORENZO
CASTRO VALLEY
San Leandro South
Mulford Gardens
Mulford Landing
Roberts Landing
SAN LORENZO
Russell City
HAYWARD
Hayward Landing
Johnson Landing
ARROYO
ALAMEDA
Union City
SALT EVAPORATORS
FREMONT
Newark
DALY CITY
Visitacion Point
Brisbane
Sierra Point
Oyster Point
Point San Bruno
S SAN FRANCISCO
Coast Guard
San Francisco International
Millbrae
SAN FRANCISCO BAY
Coyote Point
Causeway
Mussel Rock
Edgemar
Sharp Park
PACIFICA
Rockaway Beach
Point San Pedro
Devils Slide
Pt Montara
Moss Beach
Half Moon Bay
Pillar Point
El Granada
BURLINGAME
San Mateo Bridge
Guano Island
Brewer Island
Foster City
SAN MATEO
Hillsborough
Radio station
SALT EVAPORATORS
Bair Island
San Carlos
Redwood Point
Greco Island
Ravenswood Point
Dumbarton Bridge
Belmont
SAN CARLOS
REDWOOD CITY
Atherton
MENLO PARK
PALO ALTO
Dumbarton Point
Hunting lodge
SALT EVAPORATORS
ALAMEDA CO
SANTA CLARA CO
MOFFETT NAS
Half Moon Bay
MONTES
Redondo Beach
Manhattan Beach
Woodside
Portola Valley
LOS ALTOS
MOUNTAIN VIEW
SUNNYVALE
28.2


28.1
28.2
28.3
PBQ&D, Inc.
MOUNTAINS
SAN CARLOS
REDWOOD CITY
MENLO PARK
PALO ALTO
LOS ALTOS
SUNNYVALE
Saratoga
Half Moon Bay
Pescadero Point
Franklin Point
Greyhound Rock
Boulder Creek
Felton
Ben Lomond



4.1
4.2
42.1
42.2
42.3
42.4
miles
0
5
10
15
GRIZZLY ISLAND
Grizzly Island
POTRERO HILLS
Simmons Island
Wheeler Island
Roe Island
Ryer Island
Snag Island
Van Sickle Island
Denverton
Power station
Rio Vista Junction
Thompson Ranch
Hamilton Ranch
Shilo Church
Pumping station
Rio Vista
GRAND ISLAND
TYLER ISLAND
STATEN ISLAND
BRANNAN ISLAND
ANDRUS ISLAND
TWITCHELL ISLAND
BOULDIN ISLAND
SHERMAN ISLAND
WEBB TRACT
VENICE ISLAND
MANDEVILLE ISLAND
BETHEL TRACT
Franks Tract
Holland Tract
MONTEZUMA HILLS
Douglas McCormic Hill Ranch
Windmills
Toland Landing
Radio towers
Collinsville
SOLANO CO
SACRAMENTO CO
CONTRA COSTA CO
SAN JOAQUIN CO
Port Chicago
US NAVAL RES
Shore Acres
Pittsburg
Antioch
ANTIOCH
CAMP STONEMAN
Oakley
Bradford
Jersey I
CONCORD
Clayton
Pleasant Hill
WALNUT CREEK
LONE TREE VALLEY
LOS MEGANOS
BASE LINE
Brentwood
Knightsen
Discovery Bay
Victoria Island
Byron Hot Springs
Alamo
Danville
SAN RAMON
TASSAJARA
ALAMEDA COUNTY
MERIDIAN
LIVERMORE
Substation
Pumping station


43.2
43.1
42.4
42.3
LODI
STOCKTON
ROBERTS ISLAND
UNION ISLAND
NAVAL RESERVATION
EL PESCADERO
Manteca
Tracy
Lathrop
SHARPE GENERAL DEPOT
Brentwood
GRAND ISLAND
TYLER ISLAND
STATEN ISLAND
BRANNAN ISLAND
TWITCHELL ISLAND
BOULDIN ISLAND
TERMINOUS TRACT
WEBB TRACT
MANDEVILLE ISLAND
BETHEL TRACT
Holland Tract
McDONALD TRACT
RINDGE TRACT
KING ISLAND
EMPIRE TRACT
VENICE ISLAND
Lincoln Village
Victoria Island
Discovery Bay
LOS MEGANOS
SAN JOAQUIN CO
CONTRA COSTA CO
SACRAMENTO CO
Rio Vista
Deuel Vocational Institution
PBQ&D, Inc.

With the exception of Site Nos. 4 and 43, wind movement at all sites is generally moderate. Since wastewater will be kept in an aerobic condition in the conveyance, storage and application systems, no significant wind borne odors are expected.

4 - Soils

The dominant soil associations occurring in each of the sub-areas and recommended vegetative covers are given in Table II-E-2 and shown in Figure II-E-2. Since the boundaries of the sub-areas were selected on the basis of the natural drainage configuration rather than uniformity of soils, most sub-areas include a wide variety of soils. As can be seen from Table II-E-2, the soil capability classes and, to a large extent, the future uses are related to the location of the soil. Class I soils occur in the alluvial fans and flood plains and are used for rapid infiltration areas, Class II and Class III lands generally support irrigated crops while Class IV to Class VIII soils generally occur on the terraces and uplands and are devoted to pasture, range and forest uses.

The drainage characteristics of soil capability classes can, however, be reversed. The higher classed soils may have good internal and surface drainage while the low-lying soils may, although being permeable, exhibit drainage problems. These drainage problems are correctable with sub-surface drainage systems (tile or plastic drains) when the soils have adequate internal drainage.

5 - Future Land Uses

Future land uses in the sub-areas must be selected to correspond with specified objectives of wastewater application. The following gives a range of objectives that could be considered:

a) The application of maximum quantities of wastewater to minimum land areas. As a single objective this may be accomplished by the utilization of only the more permeable soils such as the Yolo, Columbia, Hanford and Hesperia associations in the recovery of maximum quantities of partially treated wastewaters. These soils could be developed using staged closed sub-surface drainage systems and a marsh grass type vegetal cover such as reed canary grass with intermittent wastewater applications.

Table II-E-2

POTENTIAL VEGETATIVE COVER
FOR WASTEWATER APPLICATION

Sheet 1

	SOIL ASSOCIATION CHARACTERISTICS				POTENTIAL VEGETATIVE COVERS AND AREAS (1000 acres) 3/												
							CROPPED AREAS										
Site Sub-Area No.	Name	Gross Area (1000 acres)	Capability Class 1/	Present Use 2/	Forest Area	Pasture Area	Alfalfa	Rice	Grain	Truck Field & Row	Orchard and Vines	Sugar Beets	Total Crops	Marsh Grasses	Total Net Area	Excluded Area	Maximum Unit Application (ft/yr) 4/
5.1 Capay Valley	Brentwood-Yolo	11.0	I	IC	---	---	---	---	---	---	---	---	---	10.4	10.4	0.6	90.0*
	Marvin-Rincon	0.7	II	IC	---	---	0.2	---	---	0.3	0.1	---	0.6	---	0.6	0.1	5.2
	Corning-Hillgate	0.4	IV	DC	---	0.4	---	---	---	---	---	---	---	---	0.4	---	9.5
	Dibble-Millsholm	40.0	VI	R	35.3	---	---	---	---	---	---	---	---	---	35.3	4.7	5.0*
	Positas	2.0	VII	R	---	---	---	---	---	---	---	---	---	---	---	2.0	---
	Rockland	13.0	VIII	F	---	---	---	---	---	---	---	---	---	---	---	13.0	---
Total		67.1	---	---	35.3	0.4	0.2	---	---	0.3	0.1	---	0.6	10.4	46.7	20.4	---
5.2 Hungry Hollow	Brentwood-Yolo	10.0	I	IC	---	---	---	---	---	---	---	---	---	9.5	9.5	0.5	90.0*
	Marvin-Rincon	13.0	II	DC	---	---	3.1	---	---	6.2	3.1	---	12.4	---	12.4	0.6	5.2
	Capay-Clear Lake	5.5	II	DC	---	5.3	---	---	---	---	---	---	---	---	5.3	0.2	9.5
	Pescadero-Willows	2.5	IV	DC,P	---	2.3	---	---	---	---	---	---	---	---	2.3	0.2	9.5
	Corning-Hillgate	5.5	IV	DC	---	5.2	---	---	---	---	---	---	---	---	5.2	0.3	9.5
	Sehorn-Balcolm	4.0	IV	R,DC	---	3.8	---	---	---	---	---	---	---	---	3.8	0.2	9.5
	Dibble-Millsholm	2.5	VII	R	2.3	---	---	---	---	---	---	---	---	---	2.3	0.2	5.0*
	Positas	1.7	VII	R	1.4	---	---	---	---	---	---	---	---	---	1.4	0.3	9.3
Total		44.7	---	---	3.7	16.6	3.1	---	---	6.2	3.1	---	12.4	9.5	42.2	2.5	---
5.3 Dunnigan Hills	Brentwood-Yolo	2.5	I	IC	---	---	---	---	---	---	---	---	---	2.4	2.4	0.1	90.0*
	Marvin-Rincon	8.5	II	IC	---	---	2.1	---	0.6	3.5	2.1	---	8.3	---	8.3	0.2	5.2
	Arbuckle-Cortina	2.3	III	IC,P	---	---	---	---	0.2	1.9	0.2	---	2.3	---	2.3	---	5.2
	Corning-Hillgate	11.5	IV	DC	---	11.3	---	---	---	---	---	---	---	---	11.3	0.2	9.5
	Sehorn-Balcolm	37.0	IV	DC,R	--	36.3	---	---	---	---	---	---	---	---	36.3	0.7	9.5
	Ayar-Rumsey	1.0	IV	R,DC	1.0	---	---	---	---	---	---	---	---	---	1.0	---	5.0*
	Dibble-Millsholm	15.5	VI	R	9.8	---	---	---	---	---	---	---	---	---	9.8	5.7	5.0*
	Positas	14.5	VII	R	12.8	---	---	---	---	---	---	---	---	---	12.8	1.7	10.0
	Altamont-Rumsey	6.0	VI	R	5.9	---	---	---	---	---	---	---	---	---	5.9	0.1	5.0*
Total		98.8	---	---	29.5	47.6	2.1	---	0.8	5.4	2.3	---	10.6	2.4	90.1	8.7	---
5.4 Yolo Plains	Brentwood-Yolo-Sycamore	39.7	I	IC	---	---	---	---	---	---	---	---	---	37.8	37.8	1.9	90.0*
	Marvin-Rincon-Tehama	12.5	II	IC	---	---	2.0	0.4	---	5.1	1.3	3.1	11.9	---	11.9	0.6	5.2
	Capay-Clear Lake-Sacramento	13.0	II	IC	---	---	2.1	0.4	---	5.3	1.4	3.2	12.4	---	12.4	0.6	5.2
	Harrington	5.3	II	IC	---	---	0.9	0.1	---	2.2	0.6	1.3	5.1	---	5.1	0.2	5.2
	Sacramento-Willows	3.7	III	DC	---	---	0.6	0.1	---	1.5	0.4	0.9	3.5	---	3.5	0.2	5.2
	Arbuckle-Cortina	6.2	III	IC,P	---	---	1.0	0.2	---	2.5	0.6	1.6	5.9	---	5.9	0.3	5.2
	Corning-Hillgate	5.9	IV	DC	---	5.4	---	---	---	---	---	---	---	---	5.4	0.5	9.5
Total		86.3	---	---	---	5.4	6.6	1.2	---	16.6	4.3	10.1	38.8	37.8	82.0	4.3	---
5.5 Yolo Bypass	Brentwood-Yolo	2.3	I	IC	---	---	---	---	---	---	---	---	---	2.1	2.1	0.2	90.0*
	Columbia-Sycamore	3.0	I	IC	---	---	---	---	---	---	---	---	---	2.7	2.7	0.3	90.0*
	Marvin-Rincon	0.7	II	IC,P	---	---	---	0.6	---	---	---	---	0.6	---	0.6	0.1	12.0
	Capay-Clear Lake-Sacramento	8.2	II	IC,P	---	---	1.9	3.7	1.8	---	---	---	7.4	---	7.4	0.8	9.0
	Columbia-Sandy Alluvial	1.9	III	P	---	---	---	---	---	---	---	---	---	1.7	1.7	0.2	90.0*
	Stockton-Sacramento	0.5	III	Rice	---	---	---	0.4	---	---	---	---	0.4	---	0.4	0.1	12.0
	Sycamore-Colusa	0.2	III	Rice	---	---	---	0.2	---	---	---	---	0.2	---	0.2	---	12.0
	Sycamore-Tyndall	3.3	IV	DC	---	---	0.6	---	---	2.1	0.3	---	3.0	---	3.0	0.3	5.4
	Corning-Hillgate	2.3	IV	DC	---	2.1	---	---	---	---	---	---	---	---	2.1	0.2	9.5
Total		22.4	---	---	---	2.1	2.5	4.9	1.8	2.1	0.3	---	11.6	6.5	20.2	2.2	---
5.6 Sacramento	Valdez-Merritt	0.6	II	IC	---	---	0.2	---	0.1	0.3	---	---	0.6	---	0.6	---	6.2
	Columbia-Lang	4.2	II,III	IC	---	---	---	---	---	---	---	---	---	4.0	4.0	0.2	90.0*
	Landlow-Marvin	2.0	III	Rice	---	---	---	0.9	---	0.6	0.4	---	1.9	---	1.9	0.1	8.2
	Stockton-Sacramento	18.0	III	P	---	---	4.3	---	4.3	6.4	2.1	---	17.1	---	17.1	0.9	6.3
	San Joaquin-Alamo	8.5	IV	P,Rice	---	---	---	---	---	---	---	---	---	---	---	8.5	---
Total		33.3	---	---	---	---	4.5	0.9	4.4	7.3	2.5	---	19.6	4.0	23.6	9.7	---
	Sorrento	1.0	I	IC	---	---	0.1	---	0.1	0.7	0.1	---	1.0	---	1.0	---	6.3
	Lost Hills	1.8	II	IC	---	---	0.2	---	0.2	1.1	0.3	---	1.8	---	1.8	---	6.3
	Pleasanton-Esparto	3.0	II	R,DC	---	---	0.3	---	0.3	1.8	0.5	---	2.9	---	2.9	0.1	6.3
	[illegible]	[illegible]	IV	R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]

	Vallecitos	26.0	VII	R	13.9	---	---	---	---	---	---	---	---	---	13.9	12.1	5.0*
Total		87.2	---	---	54.8	11.9	0.6	---	0.6	3.6	0.9	---	5.7	---	72.4	14.8	---
12.2 Dos Palos	Sorrento	0.7	I	IC	---	---	0.1	---	---	0.4	0.1	---	0.6	---	0.6	0.1	6.3
	Panoche	44.0	I	IC,P	---	---	4.3	---	4.3	27.6	6.4	---	42.6	---	42.6	1.4	6.3
	San Emigdio	28.0	I	IC,P	---	---	---	---	---	---	---	---	---	27.2	27.2	0.8	90.0*
	Lost Hills	31.5	I,II	IC,P	---	---	3.1	---	3.1	19.8	4.6	---	30.6	---	30.6	0.9	6.3
	Pleasanton-Esparto	0.5	II	R,IC	---	---	0.1	---	---	0.3	0.1	---	0.5	---	0.5	---	6.3
	Merced-Temple	1.0	II	IC,P	---	---	---	---	---	---	---	---	---	---	---	1.0	---
	Oxalis	32.0	III	IC,P	---	---	---	8.0	8.0	15.0	---	---	31.0	---	31.0	1.0	7.0
	Lethent	0.3	IV	IC,R	---	---	---	---	---	0.2	0.1	---	0.3	---	0.3	---	6.3
	Los Banos	0.7	IV	R	0.7	---	---	---	---	---	---	---	---	---	0.7	---	13.2
	Alluvial Land-Riverwash	0.1	VI	BA	---	---	---	---	---	---	---	---	---	0.1	0.1	---	90.0*
	Los Banos	0.8	VII	R,F	0.8	---	---	---	---	---	---	---	---	---	0.8	---	5.0*
	Kettleman	4.0	VII	R,F	0.9	---	---	---	---	---	---	---	---	---	---	3.1	10.0*
	Rough Rockland	0.3	VIII	BA	---	---	---	---	---	---	---	---	---	---	---	0.3	---
Total		143.9	---	---	2.4	---	7.6	8.0	15.4	63.3	11.3	---	105.6	27.3	135.3	8.6	---
18.1 Sebastopol	Pajaro	3.0	II	IC,P	---	---	---	---	---	2.6	0.3	---	2.9	---	2.9	0.1	3.5
	Clear Lake	0.6	II	IC,P	---	0.6	---	---	---	---	---	---	---	---	0.6	---	6.9
	Cotati	2.0	III	P	---	1.9	---	---	---	---	---	---	---	---	1.9	0.1	6.9
	Goldridge	9.0	IV	F,P	---	8.6	---	---	---	---	---	---	---	---	8.6	0.4	6.9
	Goldridge	0.8	VI	F,P	0.7	---	---	---	---	---	---	---	---	---	0.7	0.1	8.1
	Hugo-Laughlin-Josephine	4.0	VI	F,R,P	3.8	---	---	---	---	---	---	---	---	---	3.8	0.2	8.1
	Steinbeck-Los Osos	4.0	VI	P	---	3.8	---	---	---	---	---	---	---	---	3.8	0.2	6.9
Total		23.4	---	---	4.5	14.9	---	---	---	2.6	0.3	---	2.9	---	22.3	1.1	---
18.2 Salmon Creek	Pajaro	0.6	II	IC,P	---	---	---	---	---	0.5	0.1	---	0.6	---	0.6	---	3.5
	Goldridge	1.3	IV	F,P	---	1.2	---	---	---	---	---	---	---	---	1.2	0.1	7.0
	Rohnerville-Kneeland	2.5	IV	R,P	---	2.4	---	---	---	---	---	---	---	---	2.4	0.1	7.0
	Steinbeck-Los Osos	1.9	VI	P	---	1.8	---	---	---	---	---	---	---	---	1.8	0.1	5.0*
	Goldridge	6.3	VI	F,P	---	6.0	---	---	---	---	---	---	---	---	6.0	0.3	7.0
	Hugo-Laughlin-Josephine	6.1	VI	F,R,P	5.8	---	---	---	---	---	---	---	---	---	5.8	0.3	5.0*
	Yorkville-Sutherlin	1.3	VII	P,R	---	1.2	---	---	---	---	---	---	---	---	1.2	0.1	7.0
Total		20.0	---	---	5.8	12.6	---	---	---	0.5	0.1	---	0.6	---	19.0	1.0	---
18.3 Lagunitas Creek	Pleasanton-Zamora	1.0	II	IC	---	---	---	---	---	0.9	0.1	---	1.0	---	1.0	---	3.5
	Pajaro	3.0	II	DC,P	---	---	---	---	---	2.5	0.3	---	2.8	---	2.8	0.2	3.5
	Rohnerville-Kneeland	1.6	IV	R,P	---	1.5	---	---	---	---	---	---	---	---	1.5	0.1	6.6
	Laughlin-Parrish	3.0	VI	R,P	---	2.9	---	---	---	---	---	---	---	---	2.9	0.1	5.0*
	Los Osos	17.0	VI	P	---	16.2	---	---	---	---	---	---	---	---	16.2	0.8	5.0*
	Hugo-Josephine	5.0	VI	F	4.8	---	---	---	---	---	---	---	---	---	4.8	0.2	5.0*
	Loamy Alluvial Land	0.1	VII	R,P	---	---	---	---	---	---	---	---	---	0.1	0.1	---	90.0*
	Henneke	0.2	VII	F	---	---	---	---	---	---	---	---	---	---	---	0.2	---
	Los Gatos-Maymen	4.5	VII	R	4.3	---	---	---	---	---	---	---	---	---	4.3	0.2	7.8
Total		35.4	---	---	9.1	20.6	---	---	---	3.4	0.4	---	3.8	0.1	33.6	1.8	---
18.4, .5, .6	Pajaro	12.0	II	IC,P	---	---	---	---	---	10.3	1.1	---	11.4	---	11.4	0.6	3.5
	Yolo-Cortina-Pleasanton	5.0	II	IC	---	---	---	---	---	---	---	---	---	4.8	4.8	0.2	90.0*
	Reyes	0.2	IV	DC	---	0.2	---	---	---	---	---	---	---	---	0.2	---	7.0
	Rohnerville-Kneeland	24.0	IV	P	---	22.8	---	---	---	---	---	---	---	---	22.8	1.2	7.0
	Goldridge	3.0	VI	F,P	---	2.9	---	---	---	---	---	---	---	---	2.9	0.1	7.0
	Hugo-Laughlin-Josephine	15.0	VI	F,P,R	14.2	---	---	---	---	---	---	---	---	---	14.2	0.8	5.0*
	Los Osos	20.0	VI	P	---	19.0	---	---	---	---	---	---	---	---	19.0	1.0	5.0*
	Laughlin-Parrish	1.6	VI	R,P	---	1.5	---	---	---	---	---	---	---	---	1.5	0.1	5.0*
	Steinbeck-Los Osos	28.0	VI	P	---	26.6	---	---	---	---	---	---	---	---	26.6	1.4	5.0*
	Los Gatos-Henneke-Maymen	2.2	VII	R	2.1	---	---	---	---	---	---	---	---	---	2.1	0.1	7.8
	Yorkville-Sutherlin	1.9	VII	P,R	---	1.8	---	---	---	---	---	---	---	---	1.8	0.1	7.0
	Loamy Alluvial Land	3.0	VII	R,P	---	---	---	---	---	---	---	---	---	2.9	2.9	0.1	90.0*
	Duneland	1.4	VIII	Rec	---	---	---	---	---	---	---	---	---	---	---	1.4	---
	Tidal Flats	0.1	VIII	Rec	---	---	---	---	---	---	---	---	---	---	---	0.1	---
Total		117.4	---	---	16.3	74.8	---	---	---	10.3	1.1	---	11.4	7.7	110.2	7.2	---

Table II-E-2

POTENTIAL VEGETATIVE COVER
FOR WASTEWATER APPLICATION

Sheet 2

	SOIL ASSOCIATION CHARACTERISTICS				POTENTIAL VEGETATIVE COVERS AND AREAS (1000 acres) 3/												
							CROPPED AREAS										
Site Sub-Area No.	Name	Gross Area (1000 acres)	Capability Class 1/	Present Use 2/	Forest Area	Pasture Area	Alfalfa	Rice	Grain	Truck Field & Row	Orchard and Vines	Sugar Beets	Total Crops	Marsh Grasses	Total Net Area	Excluded Area	Maximum Unit Application (ft/yr) 4/
21.1 Alexander Valley	Yolo-Cortina-Pleasanton	7.0	II	IC	---	---	---	---	---	---	---	---	---	6.7	6.7	0.3	90.0*
	Goulding-Toomes	9.0	VI	R,P	---	8.0	---	---	---	---	---	---	---	---	8.0	1.0	5.0*
	Hugo-Laughlin-Josephine	6.0	VI	F,R,P	4.4	---	---	---	---	---	---	---	---	---	4.4	1.6	5.0*
	Los Gatos-Henneke	9.6	VII	R	---	7.9	---	---	---	---	---	---	---	---	7.9	1.7	6.4
	Yorkville-Sutherlin	11.0	VII	P,R	---	9.3	---	---	---	---	---	---	---	---	9.3	1.7	6.4
Total		42.6	---	---	4.4	25.2	---	---	---	---	---	---	---	6.7	36.3	6.3	---
21.2 Knight's Valley	Yolo-Cortina-Pleasanton	6.0	II	IC,P	---	---	---	---	---	---	---	---	---	5.8	5.8	0.2	90.0*
	Goulding-Toomes	5.0	VI	R	---	4.9	---	---	---	---	---	---	---	---	4.9	0.1	5.0*
	Hugo-Laughlin-Josephine	3.0	VI	R,P	2.9	---	---	---	---	---	---	---	---	---	2.9	0.1	5.0*
	Jiggs-Kidd-Rock	15.0	VII	R	11.3	---	---	---	---	---	---	---	---	---	11.3	3.7	8.1
	Los Gatos-Kenneke-Maymen	5.4	VII	R	1.8	---	---	---	---	---	---	---	---	---	1.8	3.6	8.1
	Sprekels-Felta	10.0	VII	R,P	9.7	---	---	---	---	---	---	---	---	---	9.7	0.3	8.1
	Yorkville-Sutherlin	16.0	VII	P,R	---	15.1	---	---	---	---	---	---	---	---	15.1	0.9	6.4
Total		60.4	---	---	25.7	20.0	---	---	---	---	---	---	---	5.8	51.5	8.9	---
21.3 Windsor	Yolo(overflow) Zamora	2.0	I	P,IC	---	---	---	---	---	---	---	---	---	1.9	1.9	0.1	90.0*
	Yolo-Cortina-Pleasanton	11.0	II	P,IC	---	---	---	---	---	---	---	---	---	10.2	10.2	0.8	90.0*
	Huichica-Wright	1.0	III	IC,P	---	---	0.1	---	---	0.2	0.6	---	0.9	---	0.9	0.1	4.1
	Spreckels-Felta	8.0	VII	R,P	7.4	---	---	---	---	---	---	---	---	---	7.4	0.6	8.8
Total		22.0	---	---	7.4	---	0.1	---	---	0.2	0.6	---	0.9	12.1	20.4	1.6	---
27.1 Gabilan Creek	Chualar	0.3	I		---	---	---	---	---	---	---	---	---	0.3	0.3	---	90.0*
	Farrallone	0.8	II	IC	---	---	---	---	---	---	---	---	---	0.8	0.8	---	90.0*
	Antioch-Gloria	0.3	VI	R,P	---	0.3	---	---	---	---	---	---	---	---	0.3	---	5.0*
	McCoy	3.0	VI	R	2.9	---	---	---	---	---	---	---	---	---	2.9	0.1	5.0*
	Los Gatos-Cotati	0.5	VI	R	---	0.5	---	---	---	---	---	---	---	---	0.5	---	9.6
	Arnold	4.0	VII	R	---	3.9	---	---	---	---	---	---	---	---	3.9	0.1	9.6
	Sheridan	12.4	VII	R	6.1	---	---	---	---	---	---	---	---	---	6.1	6.3	10.0
	Cieneba-Sheridan	2.0	VIII	F,Rec	---	---	---	---	---	---	---	---	---	---	---	2.0	---
Total		23.3	---	---	9.0	4.7	---	---	---	---	---	---	---	1.1	14.8	8.5	---
27.2 Quail Creek	Chualar	6.5	I		---	---	---	---	---	---	---	---	---	6.0	6.0	0.5	90.0*
	Salinas-Mocho	3.3	I	R	---	---	0.3	---	---	2.4	---	0.3	3.0	---	3.0	0.3	6.7
	Cropley	2.5	II		---	---	0.2	---	---	1.9	---	0.2	2.3	---	2.3	0.2	6.7
	Farrallone	2.5	II		---	---	---	---	---	---	---	---	---	2.3	2.3	0.2	90.0*
	Chualar	1.0	III	R	---	0.9	---	---	---	---	---	---	---	---	0.9	0.1	9.6
	Antioch-Gloria	1.5	III	P,DC	---	1.4	---	---	---	---	---	---	---	---	1.4	0.1	9.6
	Metz-Riverwash	1.7	IV	P,R	---	---	---	---	---	---	---	---	---	1.5	1.5	0.2	90.0*
	McCoy	11.5	VI	R	10.6	---	---	---	---	---	---	---	---	---	10.6	0.9	5.0*
	Antioch-Gloria	0.3	VI	R,P	---	0.3	---	---	---	---	---	---	---	---	0.3	---	5.0*
	Gloria-Placentia	1.4	VI,III	R	---	1.3	---	---	---	---	---	---	---	---	1.3	0.1	5.0*
	Sheridan	4.0	VII	R	---	---	---	---	---	---	---	---	---	---	---	4.0	---
	Vista	1.5	VII	R	---	---	---	---	---	---	---	---	---	---	---	1.5	---
	Cieneba-Sheridan	10.0	VIII	F,Rec	---	---	---	---	---	---	---	---	---	---	---	10.0	---
Total		47.7	---	---	10.6	3.9	0.5	---	---	4.3	---	0.5	5.3	9.8	29.6	18.1	---
27.3, .4, .5	Chualar	8.5	I		---	---	---	---	---	---	---	---	---	8.1	8.1	0.4	90.0*
	Salinas-Mocho	5.0	I	R	---	---	0.5	---	---	3.7	---	0.5	4.7	---	4.7	0.3	6.7
	Clear Lake-Pacheco	0.1	II		---	---	0.1	---	---	---	---	---	0.1	---	0.1	0	6.7
	Cropley	0.6	II		---	---	0.1	---	---	0.4	---	0.1	0.6	---	0.6	0	6.7
	Farrallone	3.8	II		---	---	---	---	---	---	---	---	---	3.6	3.6	0.2	90.0*
	Elkhorn	0.1	III		---	0.1	---	---	---	---	---	---	---	---	0.1	0	9.6
	Antioch-Gloria	1.0	III	P,DC,R	---	1.0	---	---	---	---	---	---	---	---	1.0	0	9.6
	Chualar	2.8	III	DC,R	---	2.6	---	---	---	---	---	---	---	---	2.6	0.2	9.6
	Placentia	6.5	III	R	---	6.2	---	---	---	---	---	---	---	---	6.2	0.3	9.6
	Metz-Riverwash	3.5	IV	P,R	---	3.3	---	---	---	---	---	---	---	---	3.3	0.2	9.6
	Gloria-Placentia	4.5	VI	R	---	4.3	---	---	---	---	---	---	---	---	4.3	0.2	5.0*
	Antioch-Gloria	7.0	VI	R,P	---	6.7	---	---	---	---	---	---	---	---	6.7	0.3	5.0*
	[illegible]	11.0	VII	R,P,W	---	10.4	---	---	---	---	---	---	---	---	10.4	0.6	9.6
	[illegible]														3.3	0.2	10.0

	Sweeny-Mindego	7.0	VII	R,F	6.7	---	---	---	---	---	---	---	---	---	6.7	0.3	5.0*
	Santa Lucia-Rockland	0.3	VIII	W,Rec	---	---	---	---	---	---	---	---	---	---	0	0.3	---
Total		88.4	---	---	62.2	15.2	---	---	---	4.8	---	---	4.8	0	82.2	6.2	---
42.1 Deer Valley	Brentwood-Zamora-Sorrento-Los Robles	0.5	I	IC	---	---	---	---	---	0.1	0.4	---	0.5	---	0.5	---	6.0
	Altamont-San Benito-Linne	0.3	IV	R	---	0.3	---	---	---	---	---	---	---	---	0.3	---	9.6
	Arnold	0.4	VI	R	---	---	---	---	---	---	---	---	---	0.4	0.4	---	90.0*
	Altamont-San Benito	0.8	VI	R	---	0.8	---	---	---	---	---	---	---	---	0.8	---	9.6
Total		2.0	---	---	---	1.1	---	---	---	0.1	0.4	---	0.5	0.4	2.0	---	---
42.2 Marsh Creek	Brentwood-Zamora-Sorrento-Los Robles	2.0	I	IC	---	---	---	---	---	0.4	1.5	---	1.9	---	1.9	0.1	6.0
	Altamont-San Benito-Linne	1.5	IV	R	---	1.5	---	---	---	---	---	---	---	---	1.5	---	9.6
	Altamont-San Benito	2.1	VI	R	---	2.0	---	---	---	---	---	---	---	---	2.0	0.1	9.6
	Los Gatos-Gaviota-Sobrante	2.0	VII	R	1.9	---	---	---	---	---	---	---	---	---	1.9	0.1	10.8
	Los Osos-Millsholm-Gazos	16.5	VII	R	12.1	---	---	---	---	---	---	---	---	---	12.1	4.4	5.0*
	Rockland	3.0	VIII	W	---	---	---	---	---	---	---	---	---	---	---	3.0	---
Total		27.1	---	---	14.0	3.5	---	---	---	0.4	1.5	---	1.9	---	19.4	7.7	---
42.3 Clifton Court Forebay	Cropley-Rincon	4.3	I	IC	---	---	---	---	---	0.8	3.2	---	4.0	---	4.0	0.3	6.0
	Sacramento	0.8	III		---	---	---	---	---	0.1	0.4	---	0.5	---	0.5	0.3	6.0
	Staten-Egbert	1.0	III	P	---	0.6	---	---	---	---	---	---	---	---	0.6	0.4	9.6
	Altamont-San Benito-Linne	0.1	IV	R	---	0.1	---	---	---	---	---	---	---	---	0.1	---	9.6
	Linne-Altamont	1.0	IV		---	0.9	---	---	---	---	---	---	---	---	0.9	0.1	9.6
	Altamont-San Benito	3.0	VI	R	---	2.8	---	---	---	---	---	---	---	---	2.8	0.2	9.6
	Solano-San Ysidro	2.8	IV	R	---	2.5	---	---	---	---	---	---	---	---	2.5	0.3	9.6
Total		13.0	---	---	---	6.9	---	---	---	0.9	3.6	---	4.5	---	11.4	1.6	---
42.4	Brentwood-Zamora-Sorrento-Los Robles	9.0	I	IC	---	---	---	---	---	1.7	6.9	---	8.6	---	8.6	0.4	6.0
	Cropley-Rincon	4.6	I	IC	---	---	---	---	---	0.9	3.5	---	4.4	---	4.4	0.2	6.0
	Perkins-Kimball	0.7	III	R,IC	---	---	---	---	---	0.1	0.6	---	0.7	---	0.7	0	6.0
	Altamont-San Benito-Linne	17.2	IV	R	---	16.3	---	---	---	---	---	---	---	---	16.3	0.9	9.6
	Diablo-Altamont	4.0	IV	R	---	3.8	---	---	---	---	---	---	---	---	3.8	0.2	5.0*
	Solano-San Ysidro	2.4	IV	R	---	2.3	---	---	---	---	---	---	---	---	2.3	0.1	9.6
	Pescadero	0.6	IV	P	---	0.6	---	---	---	---	---	---	---	---	0.6	0	5.0*
	Arnold	4.0	VI	R	---	3.8	---	---	---	---	---	---	---	---	3.8	0.2	9.6
	Altamont-San Benito	17.0	VI	R	---	16.2	---	---	---	---	---	---	---	---	16.2	0.8	9.6
	Los Osos-Millsholm-Gazos	4.0	VII	R	---	3.8	---	---	---	---	---	---	---	---	3.8	0.2	5.0*
	Los Gatos-Gaviota	0.2	VII	R	---	0.2	---	---	---	---	---	---	---	---	0.2	0	9.6
	Rockland	1.8	VIII	W	---	---	---	---	---	---	---	---	---	---	0	1.8	---
Total		65.5	---	---	0	47.0	---	---	---	2.7	11.0	---	13.7	0	60.7	4.8	---
43.1 Robert's Island	Valdez-Columbia	5.0	II	IC	---	---	---	---	---	---	---	---	---	4.6	4.6	0.4	90.0*
	Sacramento	6.0	III	IC	---	5.5	---	---	---	---	---	---	---	---	5.5	0.5	9.1
	Ryde-Egbert	14.8	III	IC	---	---	4.7	---	0.7	8.2	---	---	13.6	---	13.6	1.2	6.0
Total		25.8	---	---	---	5.5	4.7	---	0.7	8.2	---	---	13.6	4.6	23.7	2.1	---
43.2 Union Island	Valdez-Columbia	5.5	II	IC	---	---	---	---	---	---	---	---	---	5.1	5.1	0.4	90.0*
	Dinuba	0.6	III		---	0.5	---	---	---	---	---	---	---	---	0.5	0.1	9.1
	Stockton-Landlow	0.1	III		---	0.1	---	---	---	---	---	---	---	---	0.1	---	9.1
	Staten-Venice	1.0	III		---	0.9	---	---	---	---	---	---	---	---	0.9	0.1	9.1
	Sacramento	0.3	III		---	0.3	---	---	---	---	---	---	---	---	0.3	---	9.1
	Ryde-Egbert	28.7	III		---	---	4.0	---	1.3	21.1	---	---	26.4	---	26.4	2.3	5.8
Total		36.2	---	---	---	1.8	4.0	---	1.3	21.1	---	---	26.4	5.1	33.3	2.9	---

PBQ&D, Inc.

NOTES:

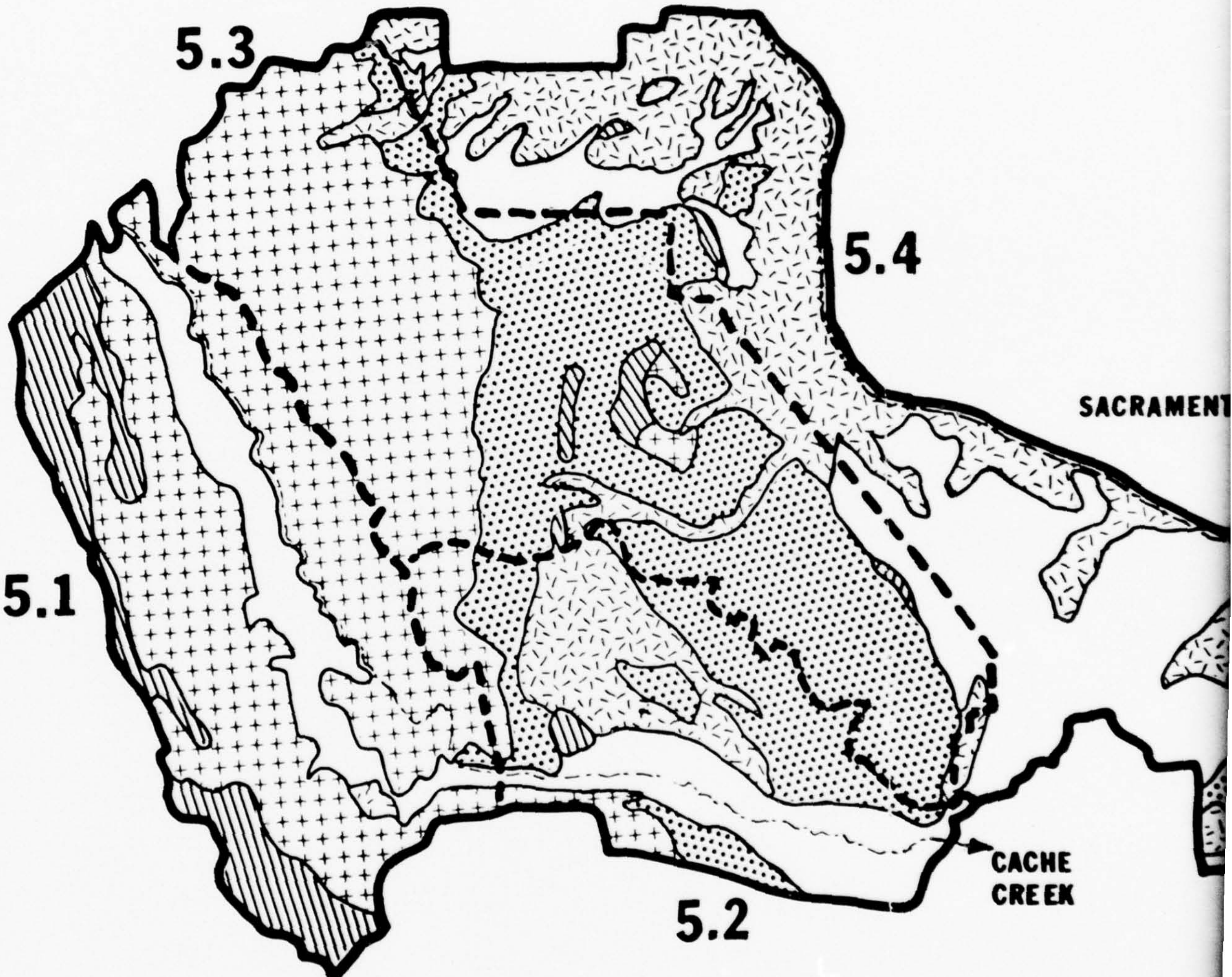
1/ Descriptions are given in Table II-C-2

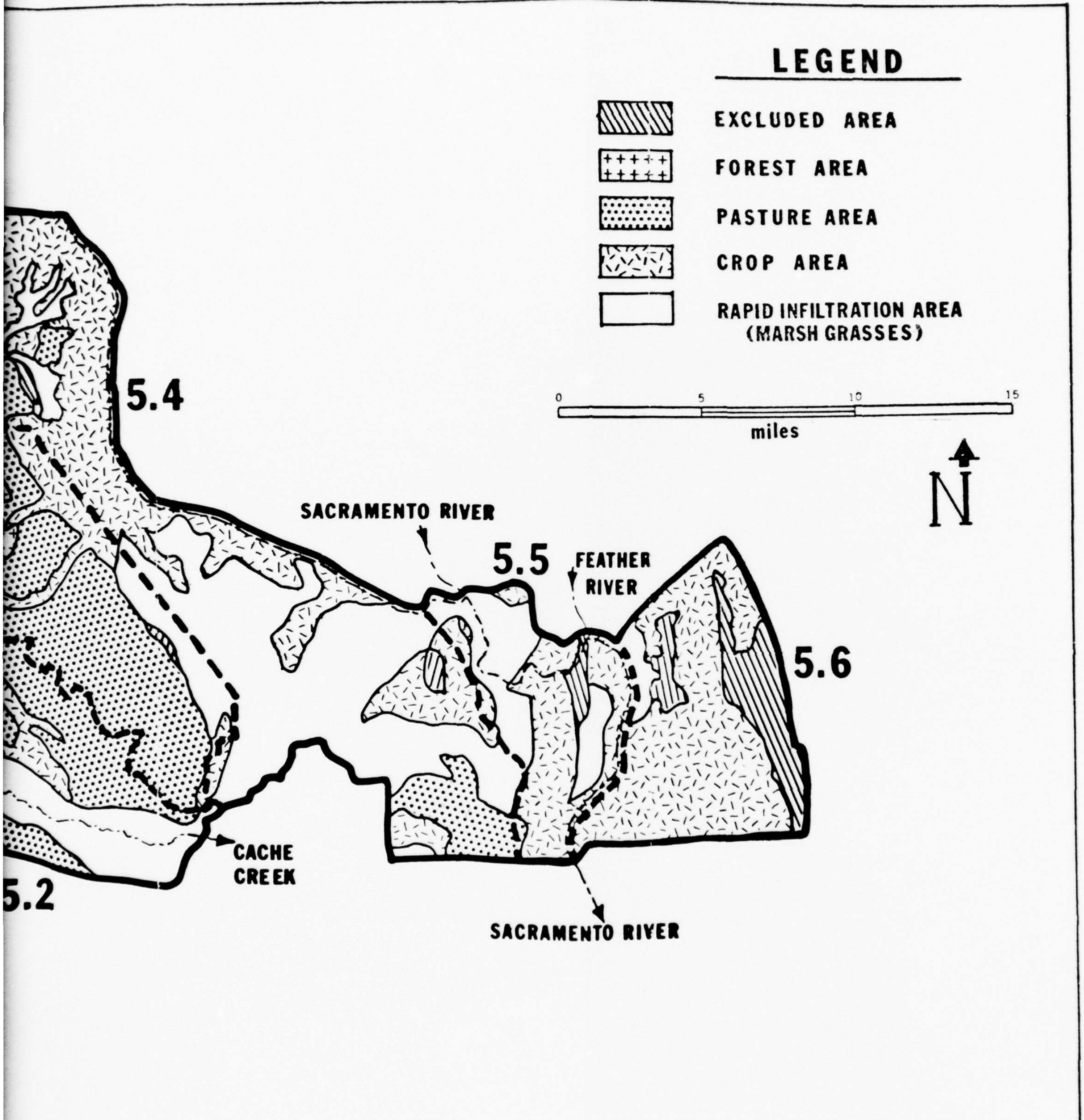
2/ IF - Infiltration Area
IC - Irrigated Cropland
DC - Dry Cropland
P - Pasture
F - Forest and Timber
R - Range
Rec- Recreation
W - Wildlife
BA - Barren
EX - Excluded

3/ Based on the following priority of use of lands:
1. Marsh grasses (Reed canary grass or other grasses tolerant to prolonged soil saturation).
2. Crops (cropping pattern consistent with established practice).
3. Pasture (rye, fescue, brome, etc.).
4. Forests (Redwood and Monterey pine).

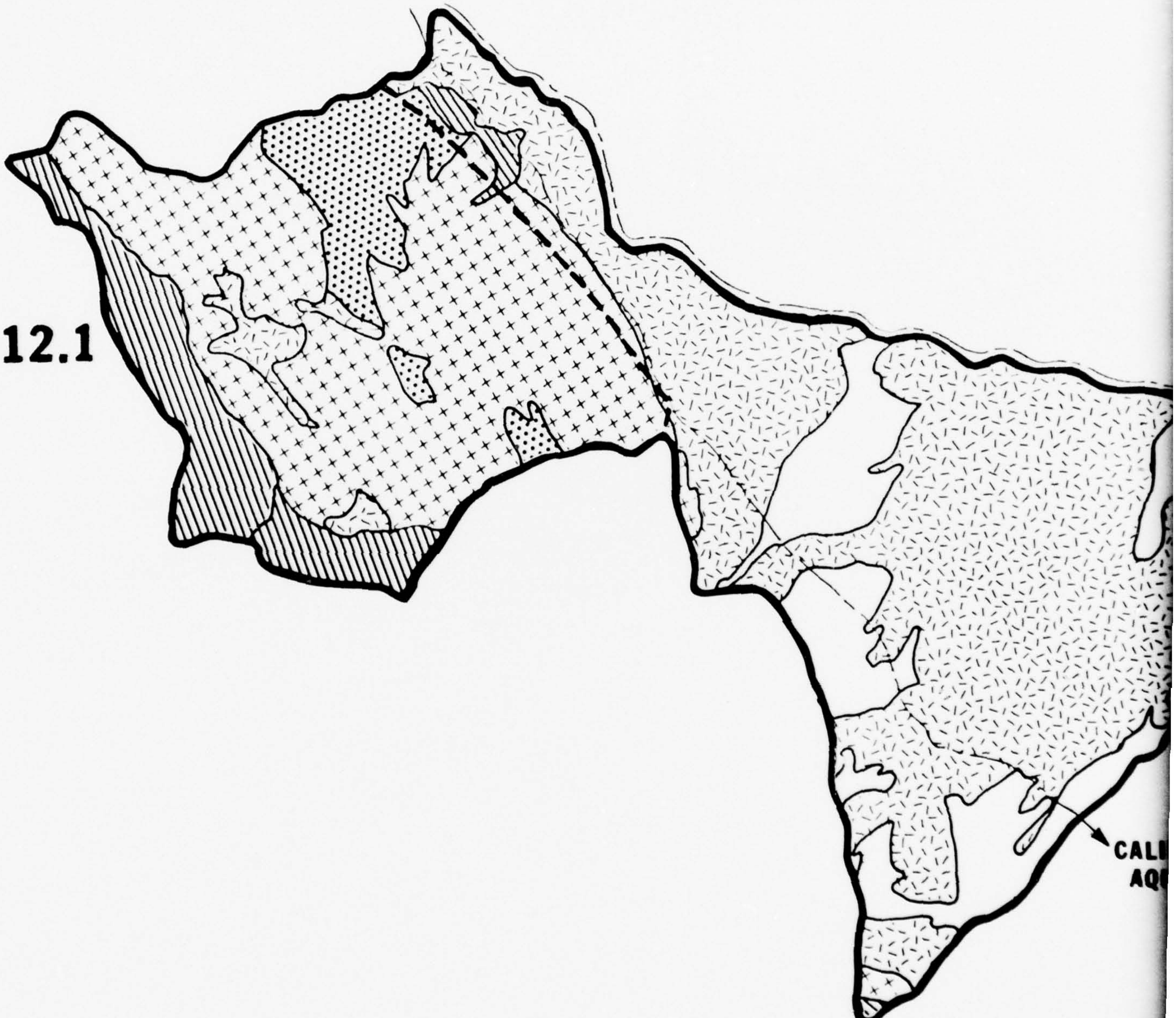
4/ Represents the maximum annual unit wastewater application rate that could be made without killing the assumed vegetative cover and is estimated as 200 percent of the site requirement of each cover plus its salt leaching requirement (see Table II-E-7). Lower unit application rates are recommended for maximum treatment of wastewater.

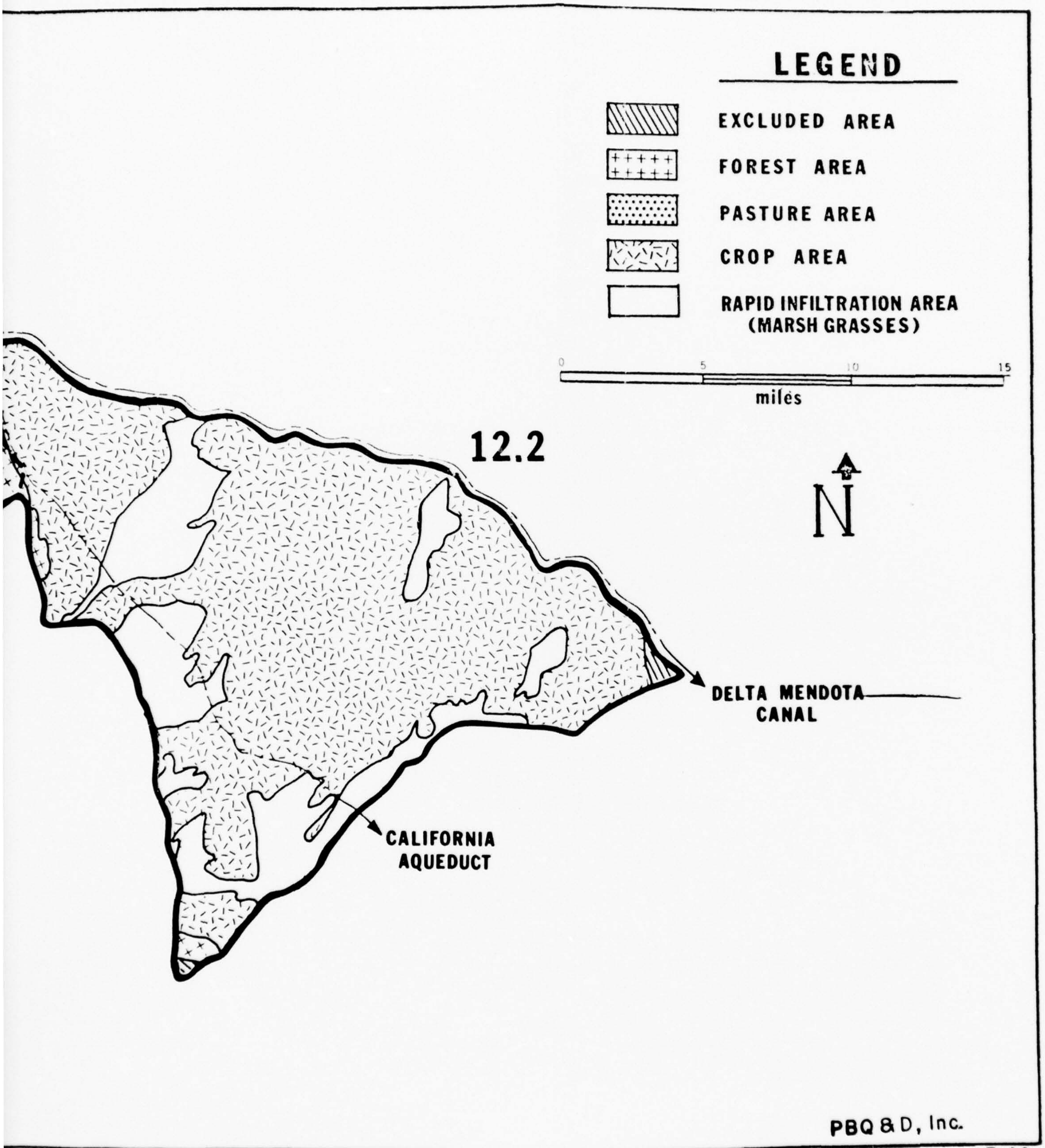
* Limited by the maximum soil application rate as given in Table II-C-2.

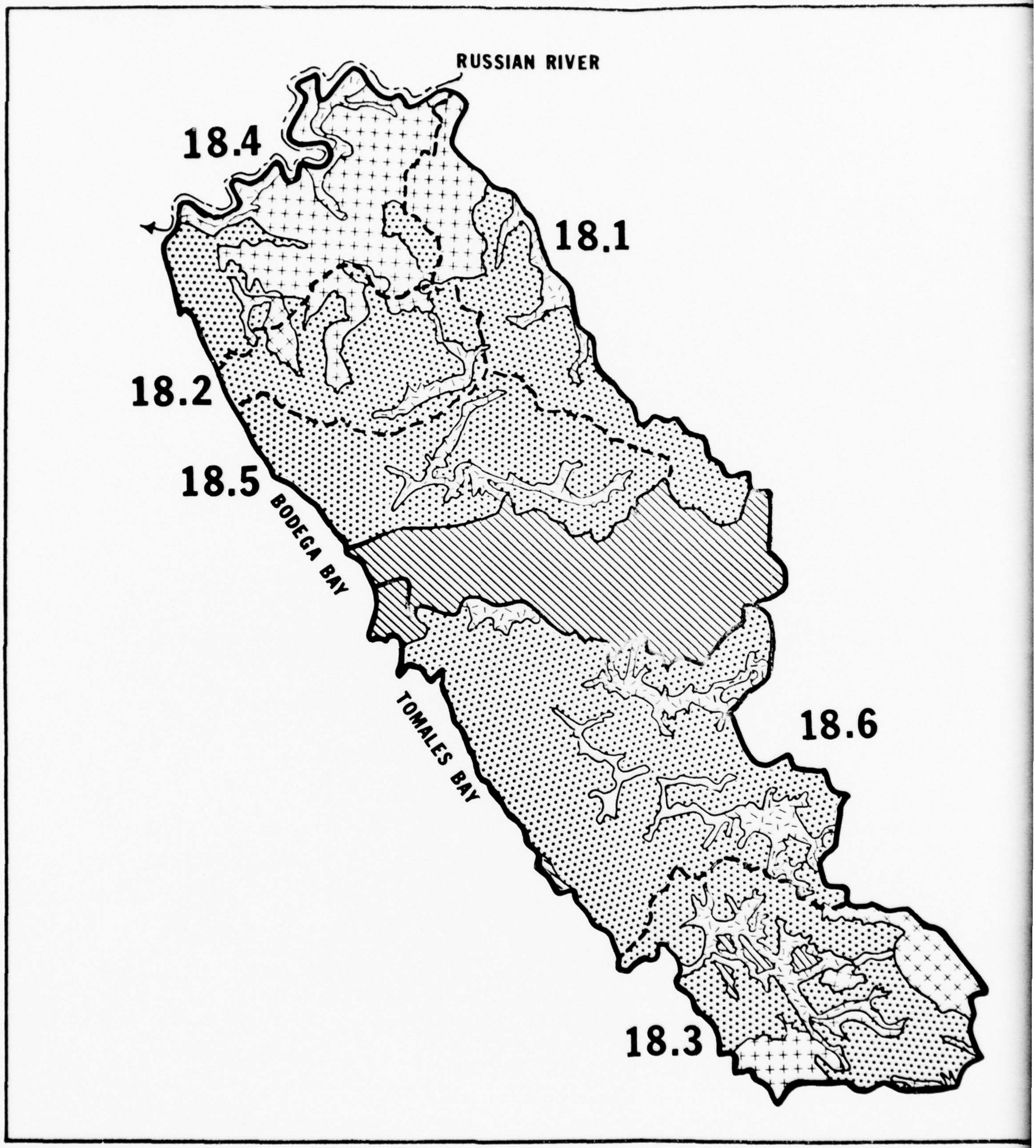

5.3
5.4
SACRAMENT
5.1
CACHE
CREEK
5.2


LEGEND
EXCLUDED AREA
FOREST AREA
PASTURE AREA
CROP AREA
RAPID INFILTRATION AREA (MARSH GRASSES)
0
5
10
15
miles
N
5.4
SACRAMENTO RIVER
5.5
FEATHER RIVER
5.6
CACHE CREEK
5.2
SACRAMENTO RIVER
PBQ&D, Inc.

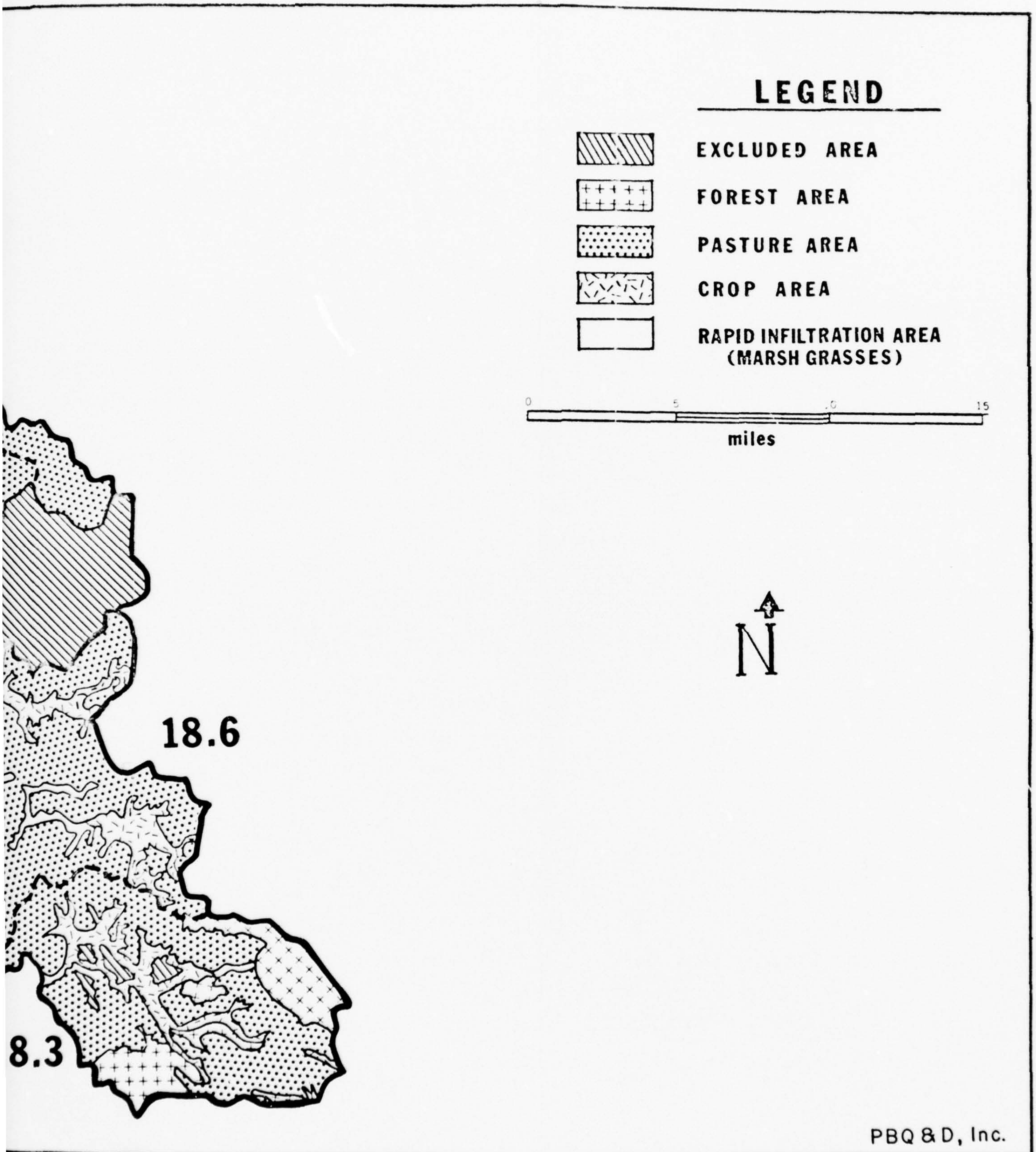
12.1

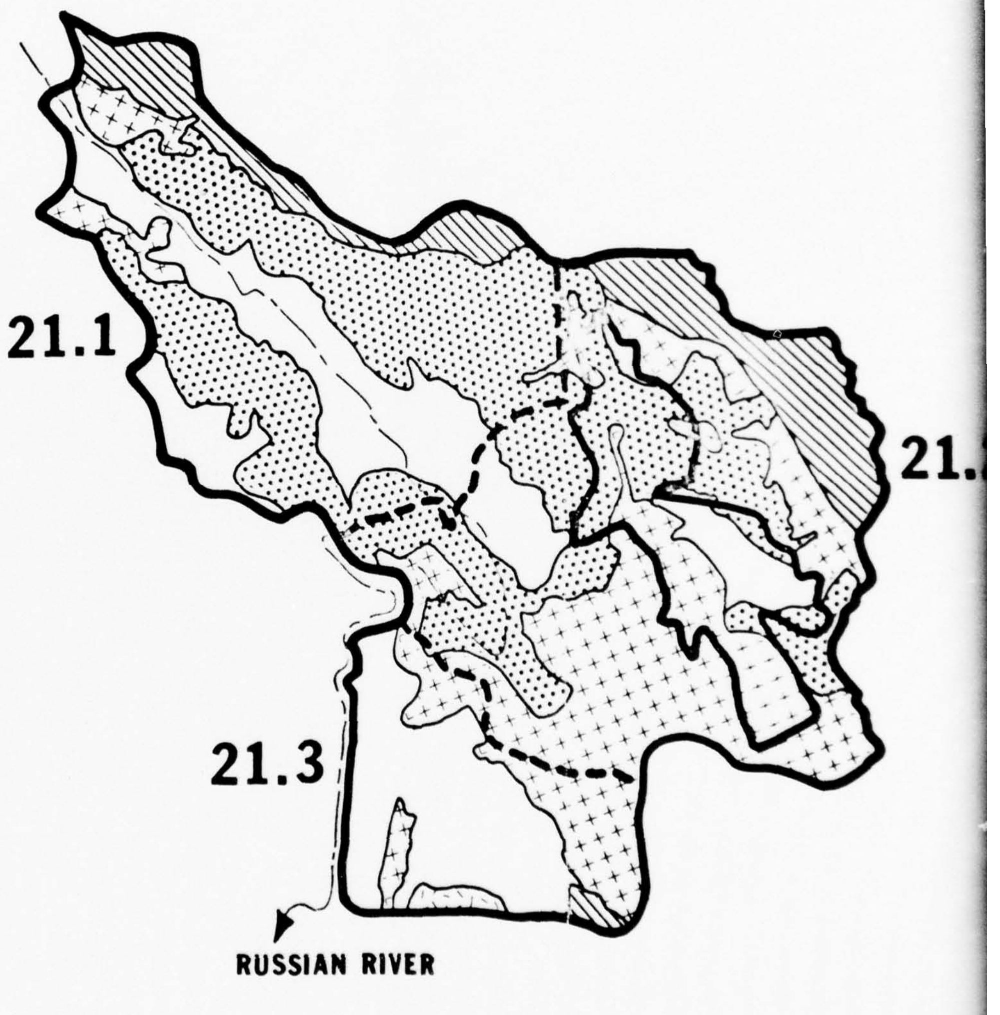


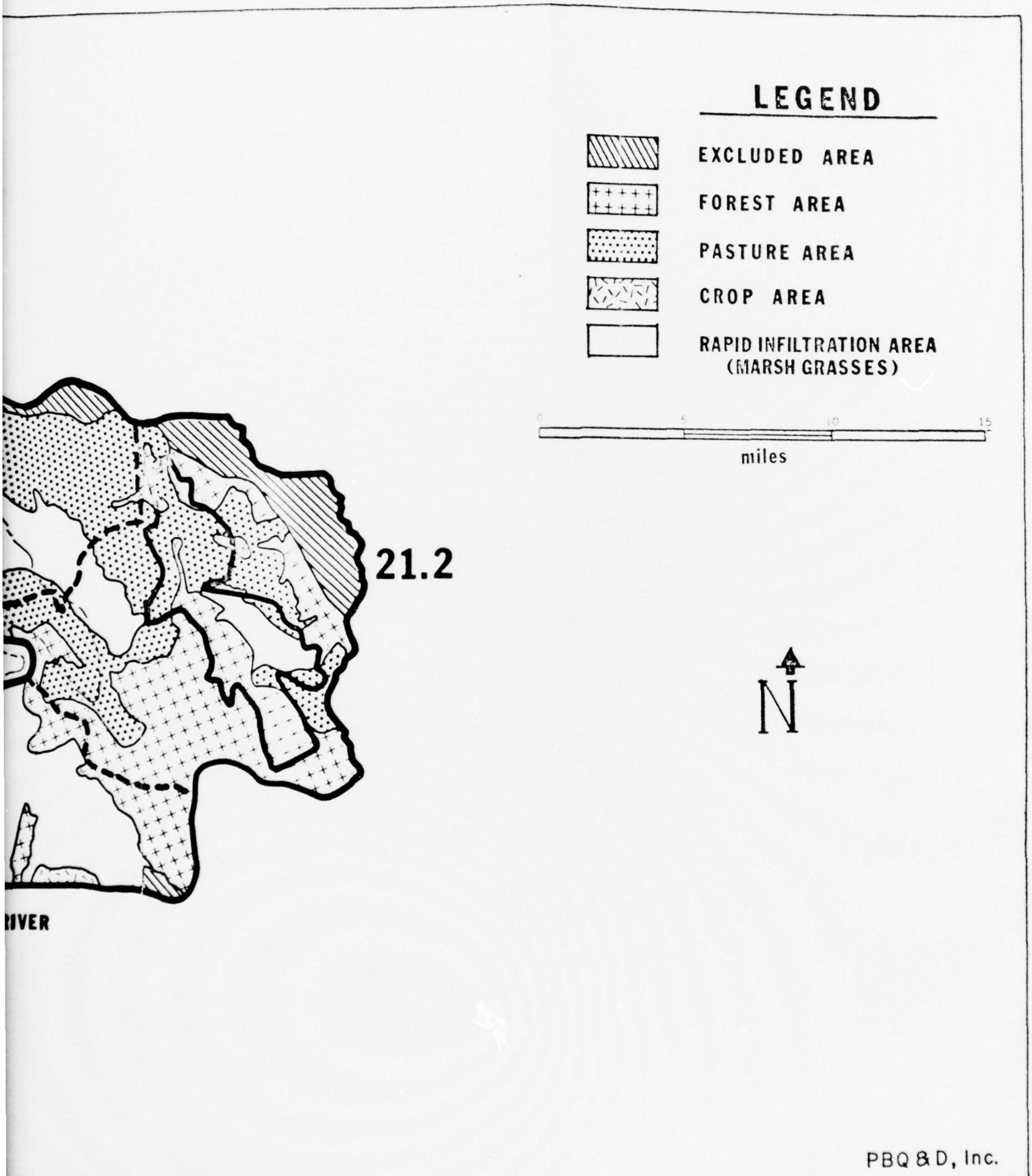

LEGEND
EXCLUDED AREA
FOREST AREA
PASTURE AREA
CROP AREA
RAPID INFILTRATION AREA (MARSH GRASSES)
0
5
10
15
miles
12.2
N
DELTA MENDOTA CANAL
CALIFORNIA AQUEDUCT
PBQ & D, Inc.

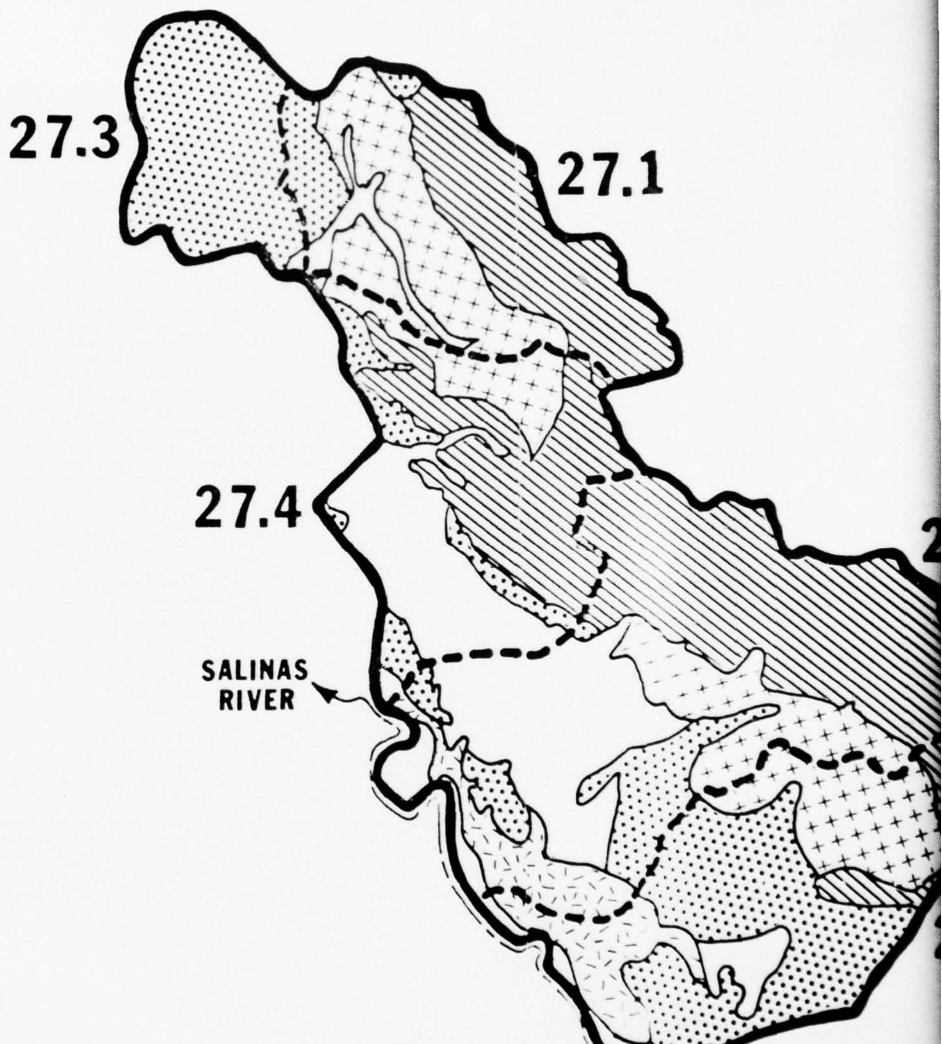


RUSSIAN RIVER
18.4
18.1
18.2
18.5
BODEGA BAY
TOMALES BAY
18.6
18.3

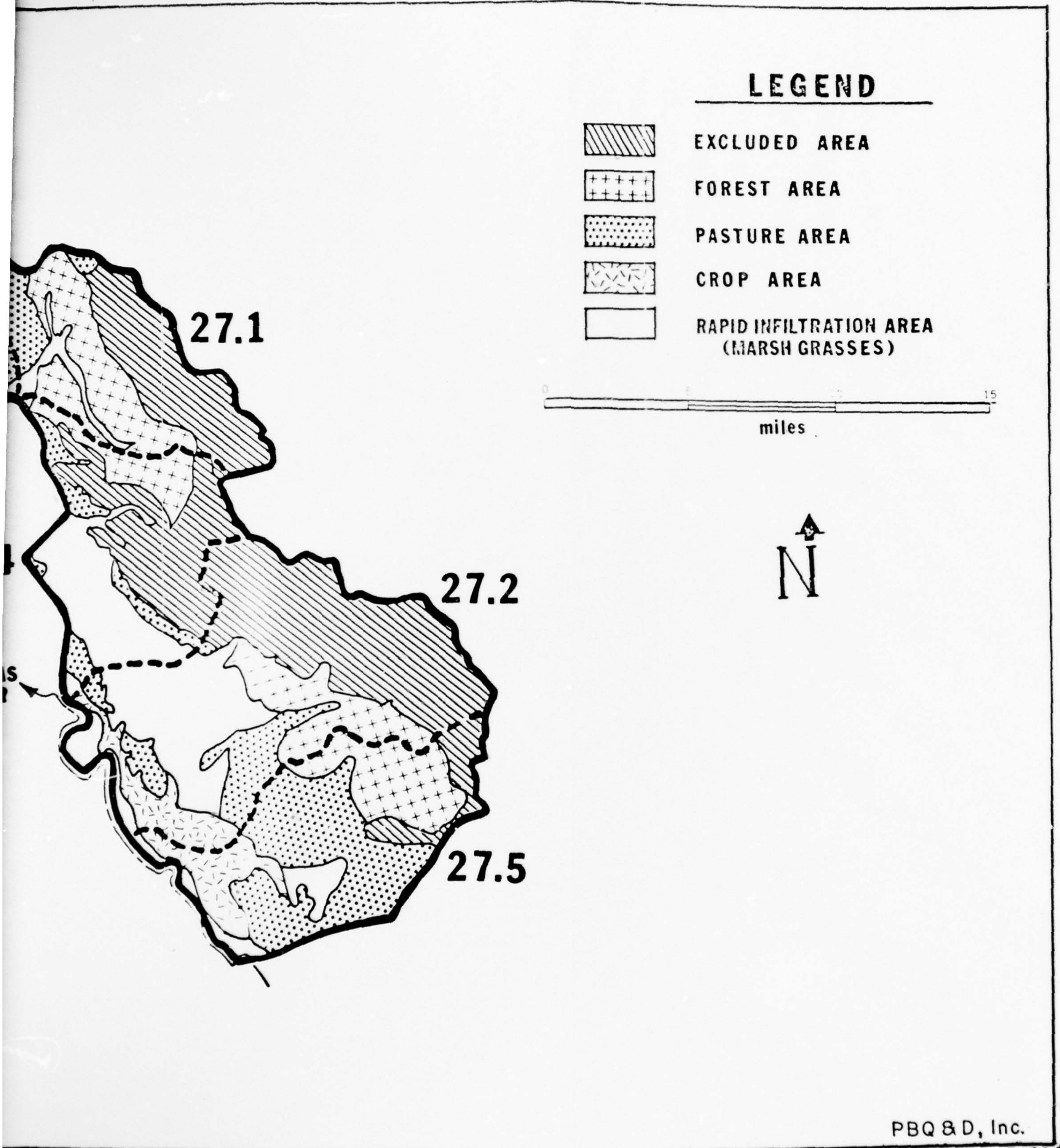

LEGEND
EXCLUDED AREA
FOREST AREA
PASTURE AREA
CROP AREA
RAPID INFILTRATION AREA
(MARSH GRASSES)
0
5
10
15
miles
N
18.6
8.3
PBQ &D, Inc.


21.1
21.3
RUSSIAN RIVER


LEGEND
EXCLUDED AREA
FOREST AREA
PASTURE AREA
CROP AREA
RAPID INFILTRATION AREA
(MARSH GRASSES)
0
5
10
15
miles
21.2
RIVER
N
PBQ & D, Inc.



27.3
27.1
27.4
SALINAS RIVER


LEGEND
EXCLUDED AREA
FOREST AREA
PASTURE AREA
CROP AREA
RAPID INFILTRATION AREA
(MARSH GRASSES)
0
15
miles
N
27.1
27.2
27.5

PBQ & D, Inc.

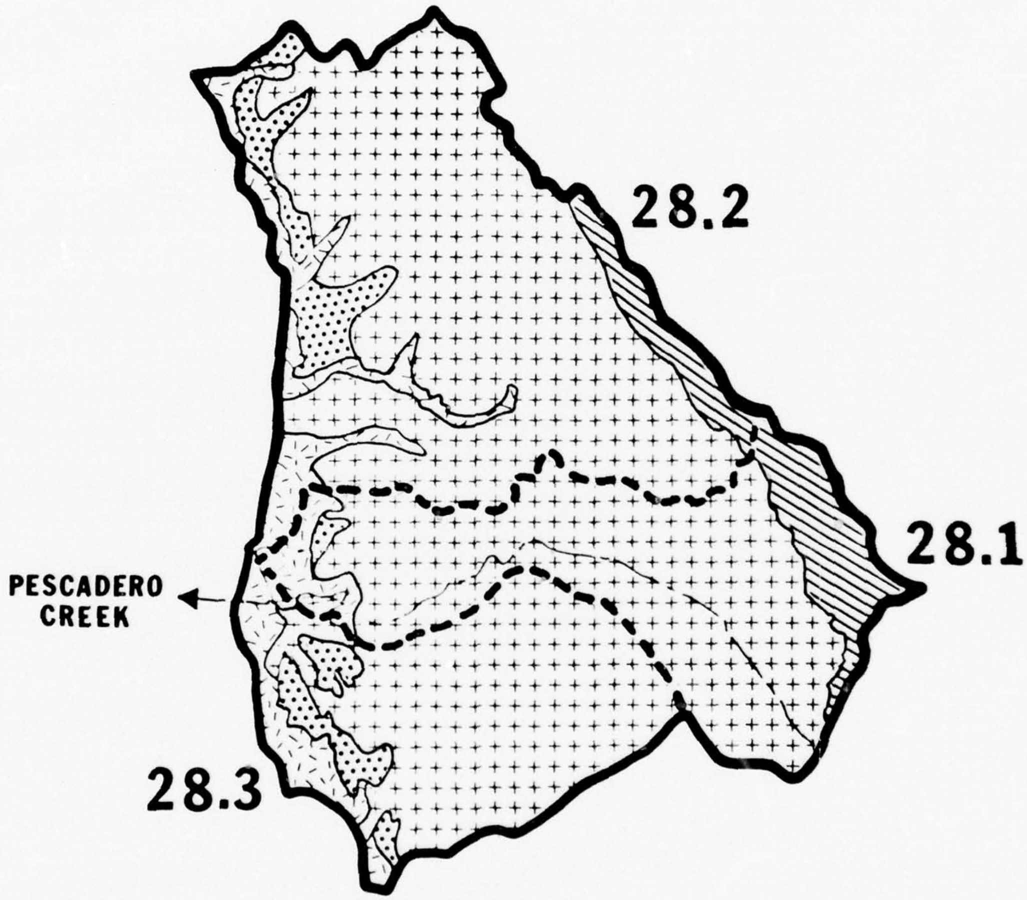
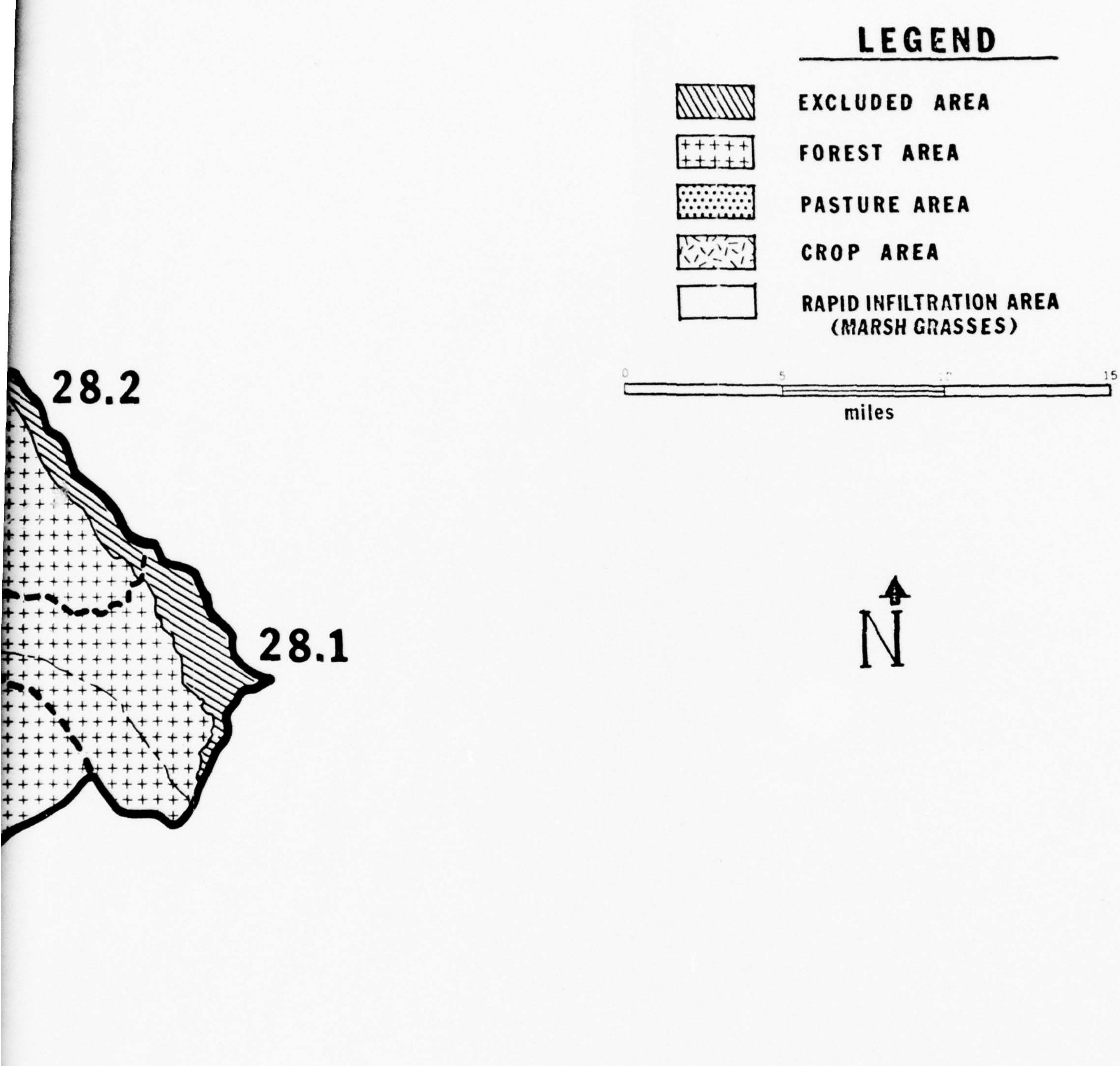

28.2
28.1
PESCADERO
CREEK
28.3

Figure II-E-2



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Note:
This site includes the Grizzly Island Wildlife Refuge (state operated) and private hunting clubs which are managed for wildlife enhancement. The land use shown indicates soil capabilities.

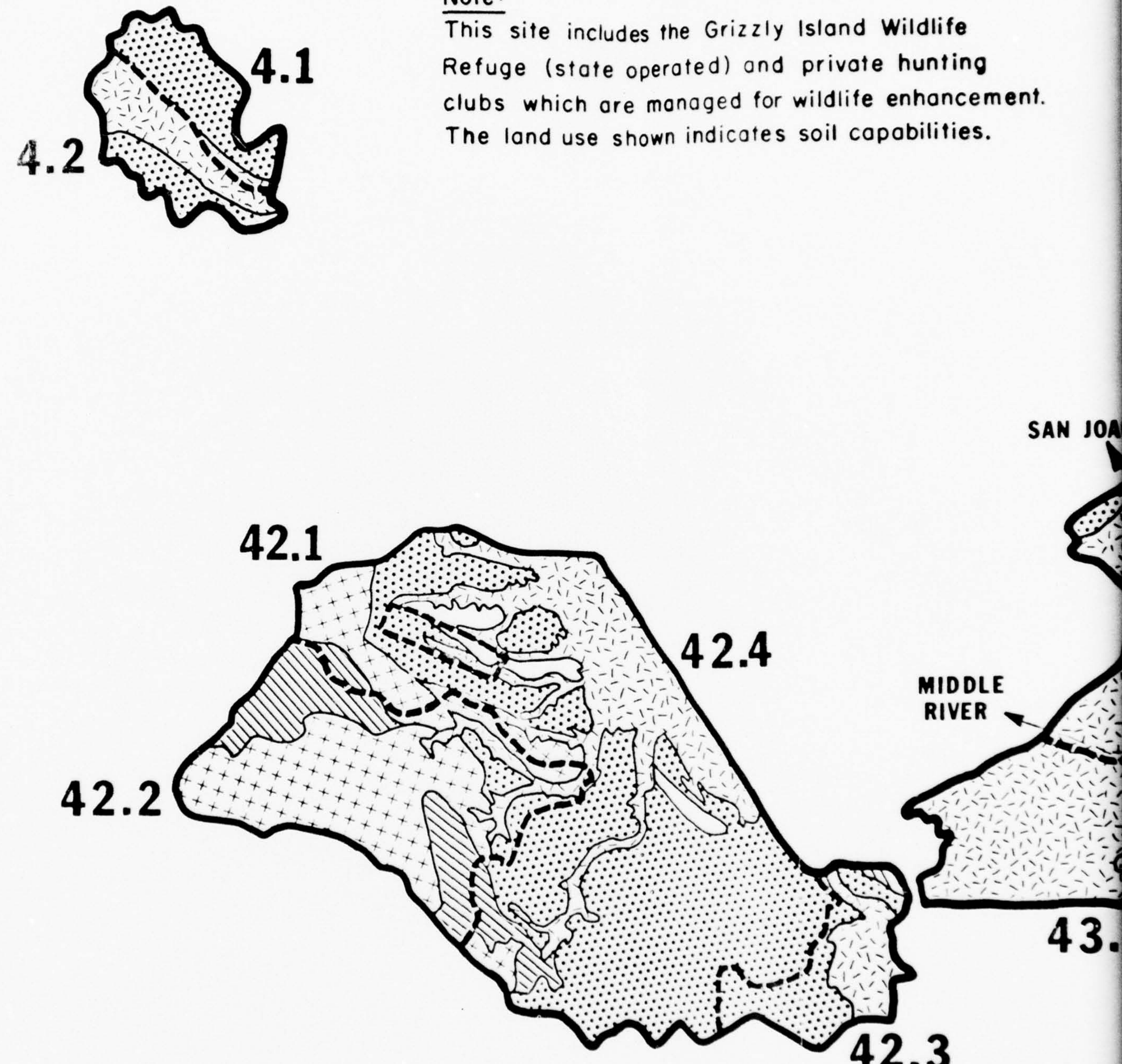
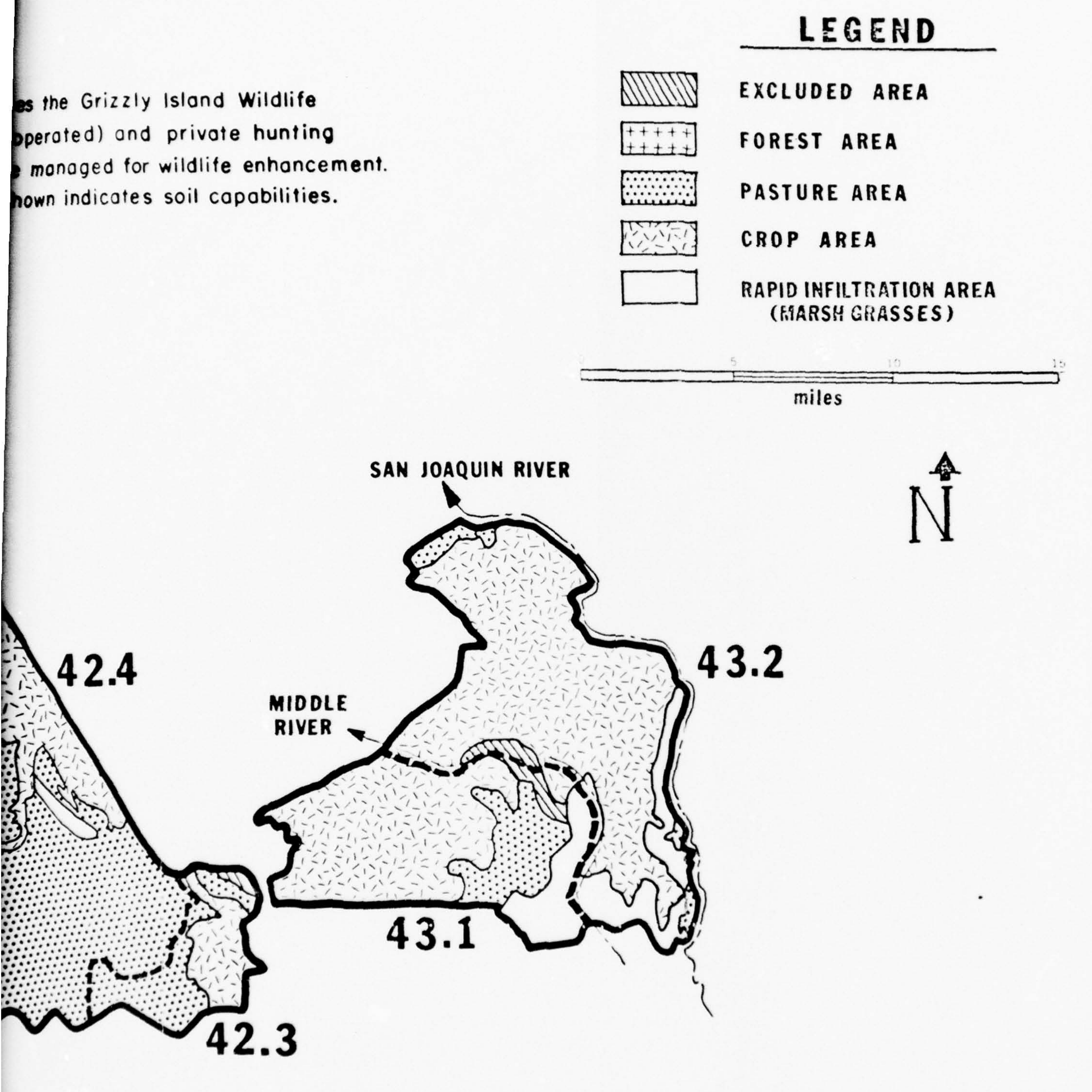


Figure II-E-2

es the Grizzly Island Wildlife
operated) and private hunting
managed for wildlife enhancement.
hown indicates soil capabilities.



PBQ & D, Inc.

b) The maximization of economic crop returns from vegetal cover harvests and maximum treatment of the recovered waters. This objective would lead to maximum development of a greater range of soils which are suitable for high value crops.

c) The maximum enhancement of the cultural and aesthetic values (and hence the public acceptance) of sites by the inclusion of forest plantations in the site land use pattern. Such an objective has merit not only in terms of public acceptance but also in the production of a timber harvest which can make a contribution to the total regional resource. Forest plantations can thrive on upland soils which are not suitable for other uses.

d) The maximum treatment of wastewaters applied to the minimum land area. This objective could be realized by cultivating pasture on all soils that are suitable for crops and rapid infiltration application.

The preceding land uses are not mutually exclusive nor are they completely interchangeable. As an example, forests and pasture can be placed on croplands and rapid infiltration areas and crops can occupy rapid infiltration areas, but crops may not necessarily be appropriate for pasture and forest lands. In addition, there are limited areas of the soil types in each sub-area which can support a particular land use practice. Therefore, development of the full potential of a sub-area will require some combination of land uses whereas selected development can be confined to only those lands having soils that are suited to the selected land use.

Table II-E-2 gives the potential land uses of each soil association found in the sites. Alternative land use patterns are given in Tables II-E-3 through Table II-E-5. Alternative No. 1 allows crops to occupy the maximum area consistent with the potential land use by soil groups. This alternative probably represents maximum gross economic return to the land. Alternative No. 2 in Table II-E-4 is selected to show higher application and recovery rates and allows pasture grasses to occupy the lands suitable for rapid infiltration areas. A greater area of pasture at the expense of cropped area would increase the overall wastewater application rate in Alternative No. 2 but would tend to upset present land use practices. Alternative No. 3, shown in Table II-E-5, is selected to maximize application and recovery rates by placing marsh grasses on the rapid infiltration areas.

The preceding land use patterns do not consider double cropping (planting and harvesting two or more distinct crops on the same acre in one year). Since double cropping is now practiced on less than ten percent of the irrigated area and is not projected to increase substantially in the future (Ref. 5), the practice probably does not increase economic returns greatly. Also the water use of a double cropped acre will approach the water use of an acre of pasture or forest. Hence, there is only a minor advantage to double cropping over pasture in those portions of the sites suitable for crop and rapid infiltration uses.

Table II-E-3

ALTERNATIVE #1 - MAXIMUM CROPPED AREA WITH RECOMMENDED ANNUAL APPLICATION RATES 1/

Site Sub-Area No.	Forest		Pasture		Crop		Rapid Infiltration (used for crops)		Total Net Area (1000 acres)	Total Annual Application (1000 acre feet)	Estimated Annual Recovery (1000 acre feet) 3/
	Net Area (1000 acres)	Unit Application Rate (acre ft per acre)	Net Area (1000 acres)	Unit Application Rate (acre ft per acre)	Net Area (1000 acres)	Unit Application Rate (acre ft per acre) 2/	Net Area (1000 acres)	Unit Application Rate (acre ft per acre)			
5.1	35.3	5.0*	0.4	5.0	0.6	3.2	10.4	3.2	46.7	213.7	99.5
5.2	2.3 1.4	5.0* 5.5	16.6	5.0	12.4	3.1	9.5	3.1	42.2	170.1	66.0
5.3	16.7 12.8	5.0* 5.9	47.6	5.0	10.6	3.2	2.4	3.2	90.1	438. 6	160.5
5.4	-0-	---	5.4	5.0	38.8	3.0	37.8	3.0	82.0	251.8	107.1
5.5	-0-	---	2.1	5.0	1.2 7.4 3.0	7.2 5.4 3.2	6.5	5.4	20.2	103.8	34.7
5.6	-0-	---	-0-	---	17.7 1.9	3.8 4.9	4.0	3.8	23.6	91.8	36.6
Total									304.8	1269.8	504.4
12.1	40.9 13.9	7.8 5.0*	11.9	5.4	5.7	3.8	-0-	---	72.4	474.4	181.1
12.2	1.6 0.8	7.1 5.0*	-0-	---	31.0 74.6	4.2 3.8	27.3	3.8	135.3	532.8	212.4
Total									207.7	1007.2	393.5
18.1	4.5	4.8	14.9	3.8	2.9	2.1	-0-	---	22.3	84.3	39.0
18.2	5.8	4.6	12.6	3.9	0.6	2.1	-0-	---	19.0	77.1	38.7
18.3	9.1	4.6	20.6	3.5	3.8	2.1	0.1	2.1	33.6	122.2	55.8
18.4,5,6	16.3	4.6	74.8	3.9	11.4	2.1	7.7	2.1	110.2	406.8	202.7

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.4	2.1	7.7	2.1	110.2	[illegible]	[illegible]
Total									185.1	690.4	336.2
21.1	4.4	4.9	25.2	3.4	-0-	---	6.7	2.4	36.3	123.3	69.4
21.2	25.7	4.8	20.0	3.4	-0-	---	5.8	2.4	51.5	205.3	118.6
21.3	7.4	5.2	-0-	---	0.9	4.1	12.1	2.4	20.4	71.2	40.5
Total									108.2	399.8	228.5
27.1	6.1 2.9	5.9 5.0*	4.4 0.3	5.1 5.0*	-0-	---	1.1	3.7	14.8	78.5	30.6
27.2	10.6	5.0*	2.3 1.6	5.1 5.0*	5.3	3.7	9.8	3.7	29.6	128.6	52.8
27.3,4, 5	3.3	5.9	23.6 11.0	5.1 5.0*	5.4	3.7	11.7	3.7	55.0	258.1	90.7
Total									99.4	465.2	174.1
28.1	29.1	4.3	0.9	3.1	2.4	3.0	-0-	---	32.4	135.1	68.5
28.2,3	62.2	4.3	15.2	3.1	4.8	3.0	-0-	---	82.2	329.0	164.6
Total									114.6	464.1	233.1
42.1	-0-	---	1.1	5.1	0.5	3.5	0.4	3.5	2.0	8.8	3.0
42.2	1.9 12.1	6.4 5.0*	3.5	5.1	1.9	3.5	-0-	---	19.4	97.2	41.6
42.3	-0-	---	6.9	5.1	4.5	3.5	-0-	---	11.4	50.9	17.2
42.4	-0-	---	38.8 8.2	5.1 5.0*	13.7	3.5	-0-	---	60.7	286.8	94.7
Total									93.5	443.7	156.5
43.1	-0-	---	5.5	4.8	13.6	3.4	4.6	3.4	23.7	88.3	32.2
43.2	-0-	---	1.8	4.8	26.4	3.4	5.1	3.4	33.3	115.7	46.4
Total									57.0	204.0	78.6
Grand Total									1170.3	4944.2	2104.9

NOTES:

1/ Wastewater application rates are taken from Table II-E-7.

* Limited by the maximum soil intake rates as shown in Table II-E-2.

2/ Wastewater application rates are weighted averages of application rates for individual crops.

3/ Estimated annual recovery in sub-surface drains or groundwater, based on the estimated water balance shown in Figure II-E-3 , recoveries calculated as follows:

Forest: A_f (0.2P + 0.2 VR + 0.7 LR)

28.1	29.1	4.3	0.9	3.1	2.4	3.0	-0-	---	32.4	135.1	68.5
28.2,3	62.2	4.3	15.2	3.1	4.8	3.0	-0-	---	82.2	329.0	164.6
Total									114.6	464.1	233.1
42.1	-0-	---	1.1	5.1	0.5	3.5	0.4	3.5	2.0	8.8	3.0
42.2	1.9 12.1	6.4 5.0*	3.5	5.1	1.9	3.5	-0-	---	19.4	97.2	41.6
42.3	-0-	---	6.9	5.1	4.5	3.5	-0-	---	11.4	50.9	17.2
42.4	-0-	---	38.8 8.2	5.1 5.0*	13.7	3.5	-0-	---	60.7	286.8	94.7
Total									93.5	443.7	156.5
43.1	-0-	---	5.5	4.8	13.6	3.4	4.6	3.4	23.7	88.3	32.2
43.2	-0-	---	1.8	4.8	26.4	3.4	5.1	3.4	33.3	115.7	46.4
Total									57.0	204.0	78.6
Grand Total									1170.3	4944.2	2104.9

NOTES:

1/ Wastewater application rates are taken from Table II-E-7.

* Limited by the maximum soil intake rates as shown in Table II-E-2.

2/ Wastewater application rates are weighted averages of application rates for individual crops.

3/ Estimated annual recovery in sub-surface drains or groundwater, based on the estimated water balance shown in Figure II-E-3 , recoveries calculated as follows:

Forest: A_f (0.2P + 0.2 VR + 0.7 LR)
Pasture: A_p (0.2 P + 0.2 VR + 0.7 LR)
Crop: A_C (0.3 P + 0.2 VR + 0.7 LR)

A = Net Area
P = Annual Precipitation (Table II-E-1)
VR = Site Requirement for Vegetation (Table II-E-7)
LR = Site Requirement for Leaching (Table II-E-7)

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Table II-E-4

ALTERNATIVE #2 - MAXIMUM PASTURE AREA WITH VEGETATION-LIMITED ANNUAL APPLICATION RATES 1/

Site Sub-Area No.	Forest		Pasture		Crop		Rapid Infiltration (used for pasture)		Total Net Area (1000 acres)	Total Annual Application (1000 acre feet)	Estimated Annual Recovery (1000 acre feet) 3/
	Net Area (1000 acres)	Unit Application Rate (acre ft per acre)	Net Area (1000 acres)	Unit Application Rate (acre ft per acre)	Net Area (1000 acres)	Unit Application Rate (acre ft per acre) 2/	Net Area (1000 acres)	Unit Application Rate (acre ft per acre)			
5.1	35.3	5.0*	0.4	9.5	0.6	5.2	10.4	9.5	46.7	282.2	134.7
5.2	2.3 1.4	5.0* 9.3	16.6	9.5	12.4	5.2	9.5	9.5	42.2	337.0	170.9
5.3	16.7 12.8	5.0* 10.0	47.6	9.5	10.6	5.2	2.4	9.5	90.1	741.6	370.0
5.4	-0-	---	5.4	9.5	38.8	5.2	37.8	9.5	82.0	612.2	311.1
5.5	-0-	---	2.1	9.5	1.2 7.4 3.0	12.0 9.0 5.4	6.5	9.5	20.2	178.9	83.8
5.6	-0-	---	-0-	---	0.6 17.1 1.9	6.2 6.3 8.2	4.0	9.5	23.6	165.0	77.9
Total									304.8	2316.9	1148.4
12.1	10.8 30.1 13.9	10.0* 13.2 5.0*	11.9	10.2	5.7	6.3	-0-	---	72.4	732.1	360.2
12.2	0.7 0.8 0.9	13.2 5.0* 10.0*	-0-	---	31.0 74.6	7.0 6.3	27.3	10.2	135.3	987.7	478.2
Total									207.7	1719.8	838.4
18.1	4.5	8.1	14.9	6.9	2.9	3.5	-0-	---	22.3	149.4	85.2
18.2	5.8	5.0*	10.8 1.8	7.0 5.0*	0.6	3.5	-0-	---	19.0	115.7	65.9
18.3	4.8	5.0*	20.6	5.0*	3.8	3.5	0.1	5.0*			

	13.9	5.0*							72.4	732.1	360.2
12.2	0.7 0.8 0.9	13.2 5.0* 10.0*	-0-	---	31.0 74.6	7.0 6.3	27.3	10.2	135.3	987.7	478.2
Total									207.7	1719.8	838.4
18.1	4.5	8.1	14.9	6.9	2.9	3.5	-0-	---	22.3	149.4	85.2
18.2	5.8	5.0*	10.8 1.8	7.0 5.0*	0.6	3.5	-0-	---	19.0	115.7	65.9
18.3	4.8 4.3	5.0* 7.8	20.6	5.0*	3.8	3.5	0.1	5.0*	33.6	174.3	94.7
18.4,5 6	2.1 14.2	7.8 5.0*	27.7 47.1	7.0 5.0*	11.4	3.5	7.7	7.0	110.2	610.6	328.1
Total									185.1	1050.0	573.9
21.1	4.4	5.0*	17.2 8.0	6.4 5.0*	-0-	---	6.7	6.4	36.3	215.0	125.3
21.2	22.8 2.9	8.1 5.0*	15.1 4.9	6.4 5.0*	-0-	---	5.8	6.4	51.5	357.4	217.0
21.3	7.4	8.8	-0-	---	0.9	4.1	12.1	6.4	20.4	146.3	79.2
Total									108.2	718.7	421.5
27.1	6.1 2.9	10.0 5.0*	4.4 0.3	9.6 5.0*	-0-	---	1.1	9.6	14.8	129.8	65.2
27.2	10.6	5.0*	2.3 1.6	9.6 5.0*	5.3	6.7	9.8	9.6	29.6	212.7	88.4
27.3,4 5	3.3	10.0	23.6 11.0	9.6 5.0*	5.4	6.7	11.7	9.6	55.0	463.1	211.8
Total									99.4	805.6	365.4
28.1	23.5 5.6	7.3 5.0*	0.9	5.9	2.4	5.2	-0-	---	32.4	217.3	126.9
28.2,3	28.9 33.3	7.3 5.0*	15.2	5.9	4.8	5.2	-0-	---	82.2	492.1	280.1
Total									114.6	709.4	407.0
42.1	-0-	---	1.1	9.6	0.5	6.0	0.4	9.6	2.0	17.4	8.6
42.2	1.9 12.1	10.8 5.0*	3.5	9.6	1.9	6.0	-0-	---	19.4	126.0	61.8
42.3	-0-	---	6.9	9.6	4.5	6.0	-0-	---	11.4	93.2	47.2
42.4	-0-	---	38.8 8.2	9.6 5.0*	13.7	6.0	-0-	---	60.7	495.7	240.4
Total									93.5	732.3	358.0
43.1	-0-	---	5.5	9.1	13.6	6.0	4.6	9.1	23.7	173.5	87.5

Total									114.6	709.4	407.0
42.1	-0-	---	1.1	9.6	0.5	6.0	0.4	9.6	2.0	17.4	8.6
42.2	1.9 12.1	10.8 5.0*	3.5	9.6	1.9	6.0	-0-	---	19.4	126.0	61.8
42.3	-0-	---	6.9	9.6	4.5	6.0	-0-	---	11.4	93.2	47.2
42.4	-0-	---	38.8 8.2	9.6 5.0*	13.7	6.0	-0-	---	60.7	495.7	240.4
Total									93.5	732.3	358.0
43.1	-0-	---	5.5	9.1	13.6	6.0	4.6	9.1	23.7	173.5	87.5
43.2	-0-	---	1.8	9.1	26.4	5.8	5.1	9.1	33.3	215.9	113.5
Total									57.0	389.4	201.0
Grand Total									1170.3	8442.1	4313.6

NOTES:

1/ Wastewater application rates are taken from Table II-E-2.

* Limited by the maximum soil intake rates as shown in Table II-E-2.

2/ Wastewater application rates are weighted averages of application rates for individual crops.

3/ Estimated annual recovery in sub-surface drains or groundwater, based on the estimated water balance shown in Figure II-E-4 , recoveries calculated as follows:

Forest: A_f (0.2P + 0.2 VR + 0.7 LR)
Pasture: A_p (0.2 P + 0.2 VR + 0.7 LR)
Crop: A_c (0.3 P + 0.2 VR + 0.7 LR)

A = Net Area
P = Annual Precipitation (Table II-E-1)
VR = Site Requirement for Vegetation (Table II-E-7)
LR = Site Requirement for Leaching (Table II-E-7)

PBQ & D, Inc.

Table II-E-5

ALTERNATIVE #3 - MAXIMUM INFILTRATION AREA WITH VEGETATION-LIMITED ANNUAL APPLICATION RATES 1/

Site Sub-Area No.	Forest		Pasture		Crop		Rapid Infiltration (Marsh Grasses)		Total Net Area (1000 acres)	Total Annual Application (1000 acre feet)	Estimated Annual Recovery (1000 acre feet) 3/
	Net Area (1000 acres)	Unit Application Rate (acre ft per acre)	Net Area (1000 acres)	Unit Application Rate (acre ft per acre)	Net Area (1000 acres)	Unit Application Rate 2/ (acre ft per acre)	Net Area (1000 acres)	Unit Application (acre ft per acre)			
5.1	35.3	5.0*	0.4	9.5	0.6	5.2	10.4	90.0*	46.7	1119.4	847.1
5.2	2.3	5.0*	16.6	9.5	12.4	5.2	9.5	90.0*			
	1.4	9.3							42.2	1101.7	820.2
5.3	16.7	5.0*	47.6	9.5	10.6	5.2	2.4	90.0*			
	12.8	10.0							90.1	934.8	534.0
5.4	-0-	---	5.4	9.5	38.8	5.2	37.8	90.0*	82.0	3655.1	2891.0
5.5	-0-	---	2.1	9.5	1.2	12.0	6.5	90.0*			
					7.4	9.0					
					3.0	5.4			20.2	702.2	527.4
5.6	-0-	---	-0-	---	0.6	6.2	4.0	90.0*			
					17.1	6.3					
					1.9	8.2			23.6	487.0	351.1
Total									304.8	8000.2	5970.8
12.1	10.8	10.0*	11.9	10.2	5.7	6.3	-0-	---			
	30.1	13.2									
	13.9	5.0*							72.4	732.1	360.2
12.2	0.7	13.2	-0-	---	31.0	7.0	27.3	90.0*			
	0.8	5.0*			74.6	6.3					
	0.9	10.0*							135.3	3166.2	2324.0
Total									207.7	3898.3	2684.2
18.1	4.5	8.1	14.9	6.9	2.9	3.5	-0-	---	22.3	149.4	85.2
18.2	5.8	5.0*	10.8	7.0	0.6	3.5	-0-	---			
			1.8	5.0*					19.0	115.7	65.9
18.3	4.8	5.0*	20.6	5.0*	3.8	3.5	0.1	90.0*			
	[illegible]	[illegible]									

12.1	10.8 30.1 13.9	10.0* 13.2 5.0*	11.9	10.2	5.7	6.3	-0-	---	72.4	732.1	360.2
12.2	0.7 0.8 0.9	13.2 5.0* 10.0*	-0-	---	31.0 74.6	7.0 6.3	27.3	90.0*	135.3	3166.2	2324.0
Total									207.7	3898.3	2684.2
18.1 18.2	4.5 5.8	8.1 5.0*	14.9 10.8 1.8	6.9 7.0 5.0*	2.9 0.6	3.5 3.5	-0- -0-	--- ---	22.3 19.0	149.4 115.7	85.2 65.9
18.3	4.8 4.3	5.0* 7.8	20.6	5.0*	3.8	3.5	0.1	90.0*	33.6	182.8	101.8
18.4,5, 6	2.1 14.2	7.8 5.0*	27.7 47.1	7.0 5.0*	11.4	3.5	7.7	90.0*	110.2	1249.7	875.6
Total									185.1	1697.6	1128.5
21.1	4.4	5.0*	17.2 8.0	6.4 5.0*	-0-	---	6.7	90.0*	36.3	775.0	604.0
21.2	22.8 2.9	8.1 5.0*	15.1 4.9	6.4 5.0*	-0-	---	5.8	90.0*	51.5	842.3	632.9
21.3	7.4	8.8	-0-	---	0.9	4.1	12.1	90.0*	20.4	1157.8	935.9
Total									108.2	2775.1	2172.8
27.1	6.1 2.9	10.0 5.0*	4.4 0.3	9.6 5.0*	-0-	---	1.1	90.0*	14.8	218.2	140.6
27.2	10.6	5.0*	2.3 1.6	9.6 5.0*	5.3	6.7	9.8	90.0*	29.6	1000.6	768.6
27.3,4, 5	3.3	10.0	23.6 11.0	9.6 5.0*	5.4	6.7	11.7	90.0*	55.0	1403.7	1021.6
Total									99.4	2622.5	1930.8
28.1	23.5 5.6	7.3 5.0*	0.9	5.9	2.4	5.2	-0-	---	32.4	217.3	126.9
28.2,3	28.9 33.3	7.3 5.0*	15.2	5.9	4.8	5.2	-0-	---	82.2	492.1	280.1
Total									114.6	709.4	407.0
42.1	-0-	---	1.1	9.6	0.5	6.0	0.4	90.0*	2.0	49.6	35.8
42.2	1.9 12.1	10.8 5.0*	3.5	9.6	1.9	6.0	-0-	---	19.4	126.0	61.8
42.3	-0-	---	6.9	9.6	4.5	6.0	-0-	---	11.4	93.2	47.2
42.4	-0-	---	38.8 8.2	9.6 5.0*	13.7	6.0	-0-	---	60.7	495.7	240.4
Total									93.5	764.5	385.2

Total									114.6	709.4	407.0
42.1	-0-	---	1.1	9.6	0.5	6.0	0.4	90.0*	2.0	49.6	35.8
42.2	1.9 12.1	10.8 5.0*	3.5	9.6	1.9	6.0	-0-	---	19.4	126.0	61.8
42.3	-0-	---	6.9	9.6	4.5	6.0	-0-	---	11.4	93.2	47.2
42.4	-0-	---	38.8 8.2	9.6 5.0*	13.7	6.0	-0-	---	60.7	495.7	240.4
Total									93.5	764.5	385.2
43.1	-0-	---	5.5	9.1	13.6	6.0	4.6	90.0*	23.7	545.7	401.4
43.2	-0-	---	1.8	9.1	26.4	5.8	5.1	90.0*	33.3	628.5	462.0
Total									57.0	1174.2	863.4
Grand Total									1170.3	21,641.8	15,542.7

NOTES:

1/ Wastewater application rates are taken from Table II-E-2.

* Limited by the maximum soil intake rates as shown in Table II-E-2.

2/ Wastewater application rates are weighted averages of application rates for individual crops.

3/ Estimated annual recovery in sub-surface drains or groundwater, based on the estimated water balance shown in Figure II-E-5 ,recoveries calculated as follows:

Forest: A_f (0.2P + 0.2 VR + 0.7 LR)
Pasture: A_p (0.2 P + 0.2 VR + 0.7 LR)
Crop: A_c (0.3 P + 0.2 VR + 0.7 LR)
Infiltration: A_i (0.7 P + 0.8 IA)

A = Net Area
P = Annual Precipitation (Table II-E-1)
VR = Site Requirement for Vegetation (Table II-E-7)
LR = Site Requirement for Leaching (Table II-E-7)
IA = Infiltration Application (Table II-E-2)

Table II-E-6

MONTHLY AND ANNUAL WASTEWATER APPLICATION REQUIREMENTS
FOR OPTIMUM VEGETATIVE GROWTH
(inches)

Sub-Area (s)		January	February	March	April	May	June	July	August	September	October	November	December	Total
4.1	Pan Evap. 1/	1.3	1.3	2.6	4.6	7.8	10.4	11.7	10.4	7.2	4.6	2.0	1.3	65.2
	PET 2/	0.9	0.9	1.8	3.2	5.5	7.3	8.2	7.3	5.0	3.2	1.4	0.9	45.6
&	Precip. 3/	3.4	3.0	2.7	1.4	0.7	0.2	0.02	0.02	0.26	0.9	1.7	2.7	17.0
	Eff. Precip. 4/	2.7	2.4	2.2	1.1	0.6	0.2	0.02	0.02	0.2	0.7	1.4	2.2	13.7
4.2	Veg. Reqm't. 5/	-0-	-0-	-0-	2.1	4.9	7.1	8.2	7.3	4.8	2.5	-0-	-0-	36.9
	Site Reqm't. 6/	-0-	-0-	-0-	3.0	7.0	10.1	11.7	10.4	6.9	3.6	-0-	-0-	52.7
5.1	Pan Evap.	1.2	2.4	3.6	4.8	7.2	9.6	12.0	9.6	8.4	4.8	2.4	1.2	67.2
	PET	0.8	1.7	2.5	3.4	5.0	6.7	8.4	6.7	5.9	3.4	1.7	0.8	47.0
	Precip.	4.1	3.5	3.1	1.8	1.3	0.4	0.1	0.1	0.4	1.3	2.4	3.5	22.0
	Eff. Precip.	3.3	2.8	2.4	1.5	1.0	0.3	0.1	-0-	0.3	1.0	1.9	2.8	17.4
	Veg. Reqm't.	-0-	-0-	0.1	1.9	4.0	6.4	8.3	6.7	5.6	2.4	-0-	-0-	35.4
	Site Reqm't.	-0-	-0-	0.1	2.7	5.7	9.2	11.9	9.6	8.0	3.4	-0-	-0-	50.6
5.2	Pan Evap.	1.2	1.8	2.9	4.7	6.5	8.2	10.0	8.8	7.0	4.1	2.4	1.2	58.8
	PET	0.8	1.3	2.0	3.3	4.6	5.7	7.0	6.2	4.9	2.9	1.7	0.8	41.1
	Precip.	3.1	2.9	2.5	1.4	1.1	0.4	0.1	0.1	0.4	1.1	2.0	2.9	18.0
	Eff. Precip.	2.5	2.3	2.0	1.1	0.9	0.3	0.1	0.1	0.3	0.9	1.6	2.3	14.4
	Veg. Reqm't.	-0-	-0-	-0-	2.2	3.7	5.4	6.9	6.1	4.6	2.0	0.1	-0-	31.0
	Site Reqm't.	-0-	-0-	-0-	3.1	5.3	7.7	9.9	8.7	6.6	2.9	0.1	-0-	44.3
5.3	Pan Evap.	1.3	1.9	3.2	5.1	7.0	8.9	10.8	9.5	7.6	4.5	2.5	1.3	63.6
	PET	0.9	1.3	2.2	3.6	4.9	6.2	7.6	6.7	5.3	3.2	1.8	0.9	44.6
	Precip.	3.1	2.9	2.5	1.4	1.1	0.4	0.1	0.1	0.4	1.1	2.0	2.9	18.0
	Eff. Precip.	2.5	2.3	2.0	1.1	0.9	0.3	0.1	0.1	0.3	0.9	1.6	[illegible]	14.4
	Veg. Reqm't.	-0-	-0-	0.2	2.5	4.0	5.9	7.5	6.6	5.0	2.3	0.2	-0-	34.2
	Site Reqm't.	-0-	-0-	0.3	3.6	5.7	8.4	10.7	9.4	7.1	3.3	0.3	-0-	48.8
5.4	Pan Evap.	1.4	2.1	3.5	5.6	7.7	9.8	12.0	10.5	8.4	4.9	2.8	1.4	69.9
	PET	1.0	1.5	2.5	3.9	5.4	6.9	8.4	7.3	5.9	3.4	2.0	1.0	49.2
	Precip.	2.9	2.5	2.2	1.3	1.0	0.3	0.1	0.1	0.3	1.0	1.8	2.5	16.0
	Eff. Precip.	2.3	2.0	1.8	1.0	0.8	0.2	0.1	0.1	0.2	0.8	1.4	2.0	12.7
	Veg. Reqm't.	-0-	-0-	0.7	2.9	4.6	6.7	8.3	7.2	5.7	2.6	0.6	-0-	39.3
	Site Reqm't.	-0-	-0-	1.0	4.1	6.6	9.6	11.9	10.3	8.1	3.7	0.9	-0-	56.2
5.5	Pan Evap.	1.4	2.1	3.5	5.6	7.7	9.8	12.0	10.5	8.4	4.9	2.8	1.4	69.9
	PET	1.0	1.5	2.5	3.9	5.4	6.9	8.4	7.3	5.9	3.4	2.0	1.0	49.2
	Precip.	2.9	2.5	2.2	1.3	1.0	0.3	0.1	0.1	0.3	1.0	1.8	2.5	16.0
	Eff. Precip.	2.3	2.0	1.8	1.0	0.8	0.2	0.1	0.1	0.2	0.8	1.4	2.0	12.7
	Veg. Reqm't.	-0-	-0-	0.7	2.9	4.6	6.7	8.3	7.2	5.7	2.6	0.6	-0-	39.3
	Site Reqm't.	-0-	-0-	1.0	4.1	6.6	9.6	11.9	10.3	8.1	3.7	0.9	-0-	56.2
5.6	Pan Evap.	1.4	2.1	3.5	5.6	7.7	9.8	12.0	10.5	8.4	4.9	2.8	1.4	69.9
	PET	1.0	1.5	2.5	3.9	5.4	6.9	8.4	7.3	5.9	3.4	2.0	1.0	49.2
	Precip.	3.1	2.7	2.4	1.4	1.0	0.3	0.1	0.1	0.3	1.0	1.9	2.7	17.0
	Eff. Precip.	2.5	2.2	1.9	1.1	0.8	0.2	0.1	0.1	0.2	0.8	1.5	2.2	13.6
	Veg. Reqm't.	-0-	-0-	0.6	2.8	4.6	6.7	8.3	7.2	5.7	2.6	0.5	-0-	39.0
	Site Reqm't.	-0-	-0-	0.9	4.0	6.6	9.6	11.9	10.3	8.2	3.7	0.7	-0-	55.9
12.1	Pan Evap.	1.5	1.5	3.0	5.3	9.1	12.1	13.6	12.1	8.3	5.3	2.3	1.5	75.6
	PET	1.1	1.1	2.1	3.7	6.4	8.5	9.5	8.5	5.8	3.7	1.6	1.0	53.0
	Precip.	2.1	2.0	1.8	1.0	0.4	0.1	-0-	-0-	0.1	0.6	1.1	1.8	11.0
	Eff. Precip.	1.7	1.6	1.4	0.8	0.3	0.1	-0-	-0-	0.1	0.5	0.9	1.4	8.8
	Veg. Reqm't.	-0-	-0-	0.7	2.9	6.1	8.4	9.5	8.5	5.7	3.2	0.7	-0-	45.7
	Site Reqm't.	-0-	-0-	1.0	4.1	8.7	12.0	13.6	12.1	8.1	4.6	1.0	-0-	65.2
	Pan Evap.	1.5	1.5	3.0	5.3	9.1	12.1	13.6	12.1	8.3	5.3	2.3	1.5	75.6
	PET	1.1	1.0	2.1	3.7	6.4	8.5	9.5	8.5	5.8	3.7	1.6	1.1	53.0
	Precip.	1.6	1.4	1.3	0.7	0.3	0.1	-0-	-0-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

5.5	Pan Evap.	1.4	2.1	3.5	5.6	7.7	9.8	12.0	10.5	8.4	4.9	2.8	1.4	69.9
	PET	1.0	1.5	2.5	3.9	5.4	6.9	8.4	7.3	5.9	3.4	2.0	1.0	49.2
	Precip.	2.9	2.5	2.2	1.3	1.0	0.3	0.1	0.1	0.3	1.0	1.8	2.5	16.0
	Eff. Precip.	2.3	2.0	1.8	1.0	0.8	0.2	0.1	0.1	0.2	0.8	1.4	2.0	12.7
	Veg. Reqm't.	-0-	-0-	0.7	2.9	4.6	6.7	8.3	7.2	5.7	2.6	0.6	-0-	39.3
	Site Reqm't.	-0-	-0-	1.0	4.1	6.6	9.6	11.9	10.3	8.1	3.7	0.9	-0-	56.2
5.6	Pan Evap.	1.4	2.1	3.5	5.6	7.7	9.8	12.0	10.5	8.4	4.9	2.8	1.4	69.9
	PET	1.0	1.5	2.5	3.9	5.4	6.9	8.4	7.3	5.9	3.4	2.0	1.0	49.2
	Precip.	3.1	2.7	2.4	1.4	1.0	0.3	0.1	0.1	0.3	1.0	1.9	2.7	17.0
	Eff. Precip.	2.5	2.2	1.9	1.1	0.8	0.2	0.1	0.1	0.2	0.8	1.5	2.2	13.6
	Veg. Reqm't.	-0-	-0-	0.6	2.8	4.6	6.7	8.3	7.2	5.7	2.6	0.5	-0-	39.0
	Site Reqm't.	-0-	-0-	0.9	4.0	6.6	9.6	11.9	10.3	8.2	3.7	0.7	-0-	55.9
12.1	Pan Evap.	1.5	1.5	3.0	5.3	9.1	12.1	13.6	12.1	8.3	5.3	2.3	1.5	75.6
	PET	1.1	1.1	2.1	3.7	6.4	8.5	9.5	8.5	5.8	3.7	1.6	1.0	53.0
	Precip.	2.1	2.0	1.8	1.0	0.4	0.1	-0-	-0-	0.1	0.6	1.1	1.8	11.0
	Eff. Precip.	1.7	1.6	1.4	0.8	0.3	0.1	-0-	-0-	0.1	0.5	0.9	1.4	8.8
	Veg. Reqm't.	-0-	-0-	0.7	2.9	6.1	8.4	9.5	8.5	5.7	3.2	0.7	-0-	45.7
	Site Reqm't.	-0-	-0-	1.0	4.1	8.7	12.0	13.6	12.1	8.1	4.6	1.0	-0-	65.2
12.2	Pan Evap.	1.5	1.5	3.0	5.3	9.1	12.1	13.6	12.1	8.3	5.3	2.3	1.5	75.6
	PET	1.1	1.0	2.1	3.7	6.4	8.5	9.5	8.5	5.8	3.7	1.6	1.1	53.0
	Precip.	1.6	1.4	1.3	0.7	0.3	0.1	-0-	-0-	0.1	0.4	0.8	1.3	8.0
	Eff. Precip.	1.3	1.1	1.0	0.6	0.2	0.1	-0-	-0-	0.1	0.3	0.6	1.0	6.3
	Veg. Reqm't.	-0-	-0-	1.1	3.1	6.2	8.4	9.5	8.5	5.7	3.4	1.0	0.1	47.0
	Site Reqm't.	-0-	-0-	1.6	4.4	8.9	12.0	13.6	12.1	8.1	4.9	1.4	0.1	67.1
18.1, .4, .5	Pan Evap.	1.7	2.3	3.5	5.2	6.9	8.0	8.6	7.5	5.8	4.0	2.3	1.7	57.6
	PET	1.2	1.6	2.5	3.6	4.8	5.6	6.0	5.3	4.1	2.8	1.6	1.2	40.3
	Precip.	7.1	6.1	4.8	2.4	1.4	0.3	-0-	-0-	0.3	1.7	3.4	6.5	34.0
	Eff. Precip.	5.7	4.9	3.8	1.9	1.1	0.2	-0-	-0-	0.2	1.4	2.7	5.2	27.1
	Veg. Reqm't.	-0-	-0-	-0-	1.7	3.7	5.4	6.0	5.3	3.9	1.4	-0-	-0-	27.4
	Site Reqm't.	-0-	-0-	-0-	2.4	5.3	7.7	8.6	7.6	5.6	2.0	-0-	-0-	39.2
18.2, .4, .5	Pan Evap.	1.7	2.3	3.5	5.2	6.9	8.0	8.6	7.5	5.8	4.0	2.3	1.7	57.6
	PET	1.2	1.6	2.5	3.6	4.8	5.6	6.0	5.3	4.1	2.8	1.6	1.2	40.3
	Precip.	9.2	7.9	6.2	3.1	1.8	0.4	-0-	-0-	0.4	2.2	4.4	8.4	44.0
	Eff. Precip.	7.4	6.3	5.0	2.5	1.4	0.3	-0-	-0-	0.3	1.8	3.5	6.7	35.2
	Veg. Reqm't.	-0-	-0-	-0-	1.1	3.4	5.3	6.0	5.3	3.8	1.0	-0-	-0-	25.9
	Site Reqm't.	-0-	-0-	-0-	1.6	4.9	7.6	8.6	7.6	5.4	1.4	-0-	-0-	37.1
18.3, .6	Pan Evap.	1.7	2.3	3.5	5.2	6.9	8.0	8.6	7.5	5.8	4.0	2.3	1.7	57.6
	PET	1.2	1.6	2.5	3.6	4.8	5.6	6.0	5.3	4.1	2.8	1.6	1.2	40.3
	Precip.	7.4	6.3	4.9	2.4	1.4	0.4	-0-	-0-	0.4	1.8	3.5	6.7	35.2
	Eff. Precip.	5.9	5.0	3.9	1.9	1.1	0.3	-0-	-0-	0.3	1.4	2.8	5.4	28.0
	Veg. Reqm't.	-0-	-0-	-0-	1.7	3.7	5.3	6.0	5.3	3.8	1.4	-0-	-0-	27.2
	Site Reqm't.	-0-	-0-	-0-	2.4	5.3	7.6	8.6	7.6	5.4	2.0	-0-	-0-	38.9
21.1	Pan Evap.	1.9	2.6	3.9	5.8	7.8	9.1	9.7	8.4	6.5	4.5	2.6	1.9	64.8
	PET	1.3	1.8	2.7	4.1	5.5	6.4	6.8	5.9	4.5	3.1	1.8	1.3	45.2
	Precip.	10.7	9.2	7.1	3.6	2.0	0.5	-0-	-0-	0.5	2.6	5.1	9.7	51.0
	Eff. Precip.	8.6	7.4	5.7	2.9	1.6	0.4	-0-	-0-	0.4	2.1	4.1	7.8	41.0
	Veg. Reqm't.	-0-	-0-	-0-	1.2	3.9	6.0	6.8	5.9	4.1	1.0	-0-	-0-	28.9
	Site Reqm't.	-0-	-0-	-0-	1.7	5.6	8.6	9.7	8.4	5.9	1.4	-0-	-0-	41.3
21.2	Pan Evap.	1.9	2.6	3.9	5.8	7.8	9.1	9.7	8.4	6.5	4.5	2.6	1.9	64.8
	PET	1.3	1.8	2.7	4.1	5.5	6.4	6.8	5.9	4.5	3.1	1.8	1.3	45.2
	Precip.	12.2	10.5	8.1	4.0	2.3	0.6	-0-	-0-	0.6	2.9	5.8	11.0	58.0
	Eff. Precip.	9.8	8.4	6.5	3.2	1.8	0.5	-0-	-0-	0.5	2.3	4.6	8.8	46.4
	Veg. Reqm't.	-0-	-0-	-0-	0.9	3.7	5.9	6.8	5.9	4.0	0.8	-0-	-0-	28.0
	Site Reqm't.	-0-	-0-	-0-	1.3	5.3	8.4	9.7	8.4	5.7	1.1	-0-	-0-	39.9
21.3	Pan Evap.	1.9	2.6	3.9	5.8	7.8	9.1	9.7	8.4	6.5	4.5	2.6	1.9	64.8
	PET	1.3	1.8	2.7	4.1	5.5	6.4	6.8	5.9	4.5	3.1	1.8	1.3	45.2
	Precip.	7.5	6.6	5.2	2.6	1.5	0.4	-0-	-0-	0.4	1.8	4.0	7.0	37.0
	Eff. Precip.	6.0	5.3	4.2	2.1	1.2	0.3	-0-	-0-	0.3	1.4	3.2	5.6	29.6
	Veg. Reqm't.	-0-	-0-	-0-	2.0	4.3	6.1	6.8	5.9	4.2	1.7	-0-	-0-	31.0
	Site Reqm't.	-0-	-0-	-0-	2.9	6.2	8.7	9.7	8.4	6.0	2.4	-0-	-0-	43.3
27.1, .3, .4	Pan Evap.	1.9	2.6	3.9	5.8	7.8	9.1	9.7	8.4	6.5	4.5	2.6	1.9	64.8
	PET	1.3	1.8	2.7	4.1	5.5	6.4	6.8	5.9	4.6	3.1	1.8	1.3	45.3
	Precip.	4.2	3.6	2.9	1.5	0.6	0.1	-0-	-0-	0.2	0.8	1.5	3.6	19.0
	Eff. Precip.	3.4	2.9	2.3	1.2	0.5	0.1	-0-	-0-	0.2	0.6	1.2	2.9	15.3
	Veg. Reqm't.	-0-	-0-	0.4	2.9	5.0	6.3	6.8	5.9	4.4	2.5	0.6	-0-	34.8
	Site Reqm't.	-0-	-0-	0.6	4.1	7.1	9.0	9.7	8.4	6.3	3.6	0.9	-0-	49.7
27.2, .4, .5	Pan Evap.	1.9	2.6	3.9	5.8	7.8	9.1	9.7	8.4	6.5	4.5	2.6	1.9	64.7
	PET	1.3	1.8	2.7	4.1	5.5	6.4	6.8	5.9	4.6	3.1	1.8	1.3	45.3
	Precip.	2.9	2.5	2.0	1.0	0.4	0.1	-0-	-0-	0.1	0.5	1.0	2.5	13.0
	Eff. Precip.	2.3	2.0	1.6	0.8	0.3	0.1	-0-	-0-	0.1	0.4	0.8	2.0	10.4
	Veg. Reqm't.	-0-	-0-	1.1	3.3	5.2	6.3	6.8	5.9	4.5	2.7	1.0	-0-	36.8
	Site Reqm't.	-0-	-0-	1.6	4.7	7.4	9.0	9.7	8.4	6.4	3.9	1.4	-0-	52.5
	Pan Evap.	1.6	2.2	3.2	4.9	6.5	7.6	8.1	7.0	5.4	3.8	2.2	1.6	54.0

27.1, .3, .4	Pan Evap.	1.9	2.6	3.9	5.8	7.8	9.1	9.7	8.4	6.5	4.5	2.6	1.9	64.8
	PET	1.3	1.8	2.7	4.1	5.5	6.4	6.8	5.9	4.6	3.1	1.8	1.3	45.3
	Precip.	4.2	3.6	2.9	1.5	0.6	0.1	-0-	-0-	0.2	0.8	1.5	3.6	19.0
	Eff. Precip.	3.4	2.9	2.3	1.2	0.5	0.1	-0-	-0-	0.2	0.6	1.2	2.9	15.3
	Veg. Reqm't.	-0-	-0-	0.4	2.9	5.0	6.3	6.8	5.9	4.4	2.5	0.6	-0-	34.8
	Site Reqm't.	-0-	-0-	0.6	4.1	7.1	9.0	9.7	8.4	6.3	3.6	0.9	-0-	49.7
27.2, .4, .5	Pan Evap.	1.9	2.6	3.9	5.8	7.8	9.1	9.7	8.4	6.5	4.5	2.6	1.9	64.7
	PET	1.3	1.8	2.7	4.1	5.5	6.4	6.8	5.9	4.6	3.1	1.8	1.3	45.3
	Precip.	2.9	2.5	2.0	1.0	0.4	0.1	-0-	-0-	0.1	0.5	1.0	2.5	13.0
	Eff. Precip.	2.3	2.0	1.6	0.8	0.3	0.1	-0-	-0-	0.1	0.4	0.8	2.0	10.4
	Veg. Reqm't.	-0-	-0-	1.1	3.3	5.2	6.3	6.8	5.9	4.5	2.7	1.0	-0-	36.8
	Site Reqm't.	-0-	-0-	1.6	4.7	7.4	9.0	9.7	8.4	6.4	3.9	1.4	-0-	52.5
28.1, .2, .3	Pan Evap.	1.6	2.2	3.2	4.9	6.5	7.6	8.1	7.0	5.4	3.8	2.2	1.6	54.0
	PET	1.1	1.5	2.2	3.4	4.6	5.3	5.7	4.9	3.8	2.9	1.5	1.1	38.0
	Precip.	8.2	7.0	5.5	2.7	1.5	0.4	-0-	-0-	0.4	1.9	4.0	7.4	39.0
	Eff. Precip.	6.6	5.6	4.4	2.2	1.2	0.3	-0-	-0-	0.3	1.5	3.2	5.9	31.2
	Veg. Reqm't.	-0-	-0-	-0-	1.2	3.4	5.0	5.7	4.9	3.5	1.4	-0-	-0-	25.1
	Site Reqm't.	-0-	-0-	-0-	1.7	4.9	7.1	8.1	7.0	5.0	2.0	-0-	-0-	35.8
42.1, .4	Pan Evap.	1.3	1.3	2.6	4.5	7.8	10.4	11.6	10.4	7.1	4.5	1.9	1.3	64.7
	PET	0.9	0.9	1.8	3.2	5.5	7.3	8.1	7.3	5.0	3.2	1.3	0.9	45.4
	Precip.	2.2	2.0	1.8	0.9	0.4	0.1	-0-	-0-	0.2	0.5	1.1	1.8	11.0
	Eff. Precip.	1.8	1.6	1.4	0.7	0.3	0.1	-0-	-0-	0.2	0.4	0.9	1.4	8.8
	Veg. Reqm't.	-0-	-0-	0.4	2.5	5.2	7.2	8.1	7.3	4.8	2.8	0.4	-0-	38.7
	Site Reqm't.	-0-	-0-	0.6	3.6	7.4	10.3	11.6	10.4	6.9	4.0	0.6	-0-	55.4
42.2, .4	Pan Evap.	1.3	1.3	2.6	4.5	7.8	10.4	11.6	10.4	7.1	4.5	1.9	1.3	64.7
	PET	0.9	0.9	1.8	3.2	5.5	7.3	8.1	7.3	5.0	3.2	1.3	0.9	45.4
	Precip.	3.6	3.2	2.9	1.5	0.7	0.2	-0-	-0-	0.3	0.9	1.8	2.9	18.0
	Eff. Precip.	2.9	2.6	2.3	1.2	0.6	0.2	-0-	-0-	0.2	0.7	1.4	2.3	14.4
	Veg. Reqm't.	-0-	-0-	-0-	2.0	4.9	7.1	8.1	7.3	4.8	2.5	-0-	-0-	36.7
	Site Reqm't.	-0-	-0-	-0-	2.9	7.0	10.1	11.6	10.4	6.9	3.6	-0-	-0-	52.5
42.3, .4	Pan Evap.	1.3	1.3	2.6	4.5	7.8	10.4	11.7	10.4	7.1	4.5	1.9	1.3	64.8
	PET	0.9	0.9	1.8	3.2	5.5	7.3	8.2	7.3	5.0	3.2	1.3	0.9	45.5
	Precip.	2.6	2.3	2.1	1.0	0.5	0.2	-0-	-0-	0.2	0.7	1.3	2.1	13.0
	Eff. Precip.	2.1	1.8	1.7	0.8	0.4	0.2	-0-	-0-	0.2	0.6	1.0	1.7	10.5
	Veg. Reqm't.	-0-	-0-	0.1	2.4	5.1	7.1	8.2	7.3	4.8	2.6	0.3	-0-	37.9
	[illegible]	[illegible]	[illegible]	0.1	3.4	7.3	10.1	11.7	10.4	6.9	3.7	0.4	-0-	54.0
43.1	Pan Evap.	1.3	1.3	2.6	4.5	7.6	10.2	11.4	10.2	7.0	4.5	1.9	1.3	63.6
	PET	0.9	0.9	1.8	3.2	5.3	7.1	8.0	7.1	4.9	3.2	1.3	0.9	44.6
	Precip.	2.2	2.0	1.8	0.9	0.4	0.1	-0-	-0-	0.2	0.5	1.1	1.8	11.0
	Eff. Precip.	1.8	1.6	1.4	0.7	0.3	0.1	-0-	-0-	0.2	0.4	0.9	1.4	8.8
	Veg. Reqm't.	-0-	-0-	0.4	2.5	5.0	7.0	8.0	7.1	4.7	2.8	0.4	-0-	37.9
	Site Reqm't.	-0-	-0-	0.6	3.6	7.1	10.0	11.4	10.1	6.7	4.0	0.6	-0-	54.1
43.2	Pan Evap.	1.3	1.3	2.6	4.5	7.6	10.2	11.4	10.2	7.0	4.5	1.9	1.3	63.6
	PET	0.9	0.9	1.8	3.2	5.3	7.1	8.0	7.1	4.9	3.2	1.3	0.9	44.6
	Precip.	2.6	2.3	2.1	1.0	0.5	0.2	-0-	-0-	0.2	0.7	1.3	2.1	13.0
	Eff. Precip.	2.1	1.8	1.7	0.8	0.4	0.2	-0-	-0-	0.2	0.6	1.0	1.7	10.5
	Veg. Reqm't.	-0-	-0-	0.1	2.4	4.9	6.9	8.0	7.1	4.7	2.6	0.3	-0-	37.0
	Site Reqm't.	-0-	-0-	0.1	3.4	7.0	9.9	11.4	10.1	6.7	3.7	0.4	-0-	52.7

NOTES:

PBQ&D, Inc.

1/ Pan Evaporation, from Bulletin 113-2, California Department of Water Resources.

2/ Potential Evapotranspiration, 0.7 x Pan Evap. (see pages 51 to 69, Bulletin 113-2)

3/ Precipitation, interpolated from iso-hyetal maps provided by the *Corps of Engineers, San Francisco.*

4/ Effective Precipitation, 0.8 x Precip.

5/ Vegetation Requirement, PET - Eff. Precip. (positive values only)

6/ Site Requirement, Veg. Reqm't./0.7

6 - Application Rates

The general relationships between application rates, vegetal cover, soil characteristics and wastewater treatment have been discussed in Section C of this report. The logical starting point in estimating application rates is the determination of crop water requirements (consumptive use) of each vegetal cover at each site. Table II-E-6 gives these estimates for each sub-area. Using Sub-Area 12.2 as an example, a vegetation receiving a full supply of moisture and nutrients and whose leaf surface completely covers the ground all year would transpire 53 inches of water. An estimated 8.0 inches would be supplied from natural precipitation and 27.0 inches would have to be supplied from the wastewater supply. Allowing for application losses, 67.1 inches or about 5.6 feet per year of wastewater should be applied to meet the vegetation's full transpiration requirement and produce optimum vegetative growth (yield).

For crops which grow during only a part of the growing season, the wastewater requirement is, of course, less. Many agricultural crops are planted and harvested during the three-month period from June through August and do not cover the ground during all of this period. Forests and pastures do transpire water during almost the entire year if there is adequate moisture available and hence are larger annual water users than most crops.

Table II-E-7 gives the recommended unit application rates for each of the four categories of recommended land uses. Each of these rates is discussed in the following sections.

Salt Leaching. The long-term accumulation of dissolved salts in surface soils is a particular hazard to maintaining most vegetative covers under an irrigation regime. Since the wastewater source will contain inorganic dissolved salts and since plant roots will uptake only the nitrate salts, most of the salts accumulate in the soil root zone unless flushed out with excess applications (leaching) during periods of low crop water requirement. Based on known tolerances of the various crops to accumulated salt concentrations, the annual site leaching requirements shown in Table II-E-7 have been computed. These requirements were also varied according to the soils found in each sub-area.

During periods of annual leaching operations, the concentration of inorganic dissolved salts in the recovered water (drainage waters)

Table II-E-7

RECOMMENDED UNIT WASTEWATER APPLICATIONS
(acre feet per acre per year)

Site Sub-Area No.	Distinguishing Feature	Land Use: Forest: Site Reqm't for Vegetation 1/	Forest: Site Reqm't for Leaching 2/	Pasture: Site Reqm't for Vegetation 1/	Pasture: Site Reqm't for Leaching 2/	Crops: Site Reqm't for Vegetation 1/	Crops: Site Reqm't for Leaching 2/
5.1	Capay Valley	3.1	1.9	4.5	0.5	2.4	0.8
5.2	Hungry Hollow	3.5	1.7	4.5	0.5	2.3	0.8
5.3	Dunnigan Hills	3.6	1.8	4.5	0.5	2.4	0.8
5.4	Yolo Plains	4.7	2.1	4.5	0.5	2.4	0.6
5.5	Yolo Bypass	4.7	2.1	4.5	0.5	5.0 3/	0.5
5.6	Sacramento	4.7	2.1	4.5	0.5	3.9 3/	0.5
12.1	Panoche	4.7	2.4	4.8	0.6	3.1	1.0
12.2	Dos Palos	3.9	2.5	4.8	0.6	3.2	1.0
18.1	Sebastopol	3.3	1.5	3.1	0.7	1.5	0.3
18.2	Salmon Creek	3.2	1.4	3.1	0.8	1.4	0.2
18.3	Lagunitas Creek	3.2	1.4	3.1	0.4	1.4	0.3
18.4,5,6	Not specific	3.2	1.4	3.1	0.8	1.5	0.6
21.1	Alexander Valley	3.4	1.5	3.0	0.4	1.7	0.7
21.2	Knight's Valley	3.3	1.5	3.0	0.4	1.7	0.7
21.3	Windsor	3.6	1.6	3.0	0.4	1.7	0.7
27.1	Gabilan Creek	3.8	1.8	4.5	0.6	2.8	0.9
27.2	Quail Creek	3.0	2.0	4.5	0.6	2.9	0.9
27.3,4,5	Not specific	4.1	1.8	4.5	0.6	2.8	0.9
28.1	Pescadero Creek	3.0	1.3	2.8	0.3	2.2	0.8
28.2,3	Not specific	3.0	1.3	2.8	0.3	2.2	0.8
42.1	Deer Valley	---	---	4.5	0.6	2.5	1.0

[illegible]	Sacramento	4.7	2.1	4.5	[illegible]	[illegible] 3/	[illegible]
12.1	Panoche	4.7	2.4	4.8	0.6	3.1	1.0
12.2	Dos Palos	3.9	2.5	4.8	0.6	3.2	1.0
18.1	Sebastopol	3.3	1.5	3.1	0.7	1.5	0.3
18.2	Salmon Creek	3.2	1.4	3.1	0.8	1.4	0.2
18.3	Lagunitas Creek	3.2	1.4	3.1	0.4	1.4	0.3
18.4,5,6	Not specific	3.2	1.4	3.1	0.8	1.5	0.6
21.1	Alexander Valley	3.4	1.5	3.0	0.4	1.7	0.7
21.2	Knight's Valley	3.3	1.5	3.0	0.4	1.7	0.7
21.3	Windsor	3.6	1.6	3.0	0.4	1.7	0.7
27.1	Gabilan Creek	3.8	1.8	4.5	0.6	2.8	0.9
27.2	Quail Creek	3.0	2.0	4.5	0.6	2.9	0.9
27.3,4,5	Not specific	4.1	1.8	4.5	0.6	2.8	0.9
28.1	Pescadero Creek	3.0	1.3	2.8	0.3	2.2	0.8
28.2,3	Not specific	3.0	1.3	2.8	0.3	2.2	0.8
42.1	Deer Valley	---	---	4.5	0.6	2.5	1.0
42.2	Marsh Creek	3.2	2.0	4.5	0.6	2.5	1.0
42.3	Clifton Court Forebay	---	---	4.5	0.6	2.5	0.9
42.4	Not specific	4.4	2.0	4.5	0.6	2.5	1.0
43.1	Roberts Island	---	---	4.3	0.5	2.6	0.8
43.2	Union Island	---	---	4.3	0.5	2.5	0.8

NOTES:

1/ Based on the growing season of each vegetative cover and includes a 30% application loss to surface waste and deep percolation below root zone (see Table II-E-6).

2/ An estimated amount required to maintain the annual salt balance within the tolerance of the recommended vegetative cover. This application should be made during off-season periods.

3/ Includes the effect of rice acreages.

will be greater than the concentration in the applied wastewater.

Forest and Pasture Application Rates. The forest and pasture application rates are based on the method of estimation given in Table II-E-6 whereas the crop application rates are based on irrigation experience in or near the sites. Few field data are available on the salt tolerance of coniferous forest species such as Redwoods and Pines. It is reasonable, however, to expect that they will be at least as tolerant as orchard species for which field data are available. The leaching applications shown in Table II-E-7 were computed from the orchard data.

Crop Application Rates. The unit application rates for crops are the weighted averages of a cropping pattern selected for the soils of each sub-area by the Special Technical Consultants for crops (Dr. James N. Luthin and Dr. James W. Biggar). The types of crops utilized were alfalfa, rice, other grains (wheat, oats and barley), truck, field, row, sugar beets, vines, deciduous orchards, safflower and beans. The unit vegetative requirement and leaching rate for each crop used was selected by the Special Technical Consultants, as applicable to the particular crop, soil and sub-area.

Infiltration Areas. Laboratory and field tests have demonstrated that free draining soils similar to the Brentwood-Yolo association (silty loams) are quite well suited to high rates of wastewater application. The SERL report (Ref. 15) suggests that an equilibrium rate of 0.16 feet per day 50% of the time (30 feet per year) can be maintained on a long-term basis. The report recommends a design value of five times this amount (150 feet per year) as a mean value. Actual wastewater application rates on sandy soils have been reported as high as 300 feet per year (Ref. 18).

The unit wastewater application rates shown in Table II-E-2 (90 feet per year) for infiltration areas assume an application rate of 1.0 feet per day and resting for three days. This value was estimated as the maximum wastewater application that could be made on the soils identified as suitable for infiltration areas (see Table II-C-2).

Over-Irrigation. Over-irrigation (as well as under-irrigation) can be practiced on nearly all vegetation but not without some reduction in yield. Even Redwood trees which are native to flood plains suffer damage in their root structures during extended innundation. They are able, however, to repair this damage after the soil has dried where many other plants cannot recover and remain in a weakened condition.

The internal drainage capacity of many of the soils available in the sites under investigation will often exceed the water requirements of the vegetative cover maintained on its surface (see Table II-C-2). Field experience at Pleasanton, California has shown that the application rate of a secondary effluent to a mixture of common grasses (rye, orchard, fescue, brome, etc.) on a Yolo type soil can be as high as 11 feet per year (about twice the farm plus leaching requirement) without serious damage to the crop and without any significant amount of surface runoff during the year. In addition, a monitoring program of the sub-surface drainage water (no sub-surface drainage system was installed) has shown it to be of acceptable quality for groundwater recharge.

Although nitrate removal will decrease with over-irrigation (see Figure II-C-7), there may be sufficient justification, based on considerations of reduced land requirements and site development costs, to apply more wastewater than is required for optimum vegetal cover growth. At present there is insufficient data available on which to base a reliable estimate of the maximum level of over-irrigation that can be maintained for each soil type and each vegetative cover. It is assumed, however, that most soils identified can survive with wastewater applied at a rate of two times the optimum growth requirement of the associated vegetation. This application rate has been assumed as the maximum rate limited by vegetation and is used in Alternatives No. 2 and 3.

Organic Loading. The organic concentration of the wastewater source (that component that is readily degradable by bacterial digestion into inorganic compounds) is closely related to the total suspended solids concentrations estimated for wastewaters from the 12-county region (20 to 40 mg/l as shown in Table II-B-10). Thus the unit organic loading from wastewater applications would range from 0.03 to 0.06 tons per acre-foot per acre. Using the recommended unit applications, forests would receive organic loadings of from 0.1 to 0.5 tons per year per acre, pasture and crops from 0.05 to 0.3 tons per acre and infiltration areas from 2.5 to 5.0 tons per acre.

Burd (Ref. 22) has suggested that organic loadings should be kept to less than 20-25 tons per acre for growing crops but that loadings for soil modification purposes (no direct cropping) can exceed 100 tons per acre. The rate of application of wastewater is not, therefore, limited by the organic loading.

Annual total nitrogen loadings will range from about 400 pounds per acre on crops to over 2500 pounds per acre on forests and pasture. These loadings will exceed in almost all cases the annual nitrogen requirements of the vegetation (assumed to average 300 pounds per acre).

The annual application of total phosphorus will range from 80 to 380 pounds per acre. Since phosphates are readily adsorbed by the soil particles, these loadings will not be of great concern.

Application Efficiency. Through very careful water management, irrigation applications can be made with little or no surface runoff. This type of management is expensive and, while practiced initially, is often abandoned when the water supply is not critically short.

In estimating values for practical and feasible application rates, we have selected a 70% irrigation efficiency (30% of the water applied for irrigation purposes is lost to either surface runoff or to the sub-surface drainage system) as a reasonable estimate of the water management effort. From this estimate, 10% is assumed to runoff and 20% passes through the root zone for all land uses.

Since the salt leaching applications are normally made during periods of low transpiration use, with the same water management practices, a greater percentage of the application can be forced through the root zone to leach accumulate salts. No leaching application would be required on the infiltration areas.

Total Applications. Tables II-E-3, II-E-4 and II-E-5 indicate the total annual wastewater applications for each sub-area under Alternatives 1, 2 and 3, respectively.

The recommended application rates shown in Table II-E-3 are taken from Table II-E-7 and are based on the growing season and site requirement of each vegetative cover and include a 30 percent application loss to surface waste and deep percolation below the root zone. For example, the annual application rate of 5.4 acre-feet per acre shown in Table II-E-3 for the pasture area in Sub-Area 12.1 is the sum of the vegetation and leaching requirements shown in Table II-E-7 and is based on the water requirement data given in Table II-E-6. These recommended application rates are discussed on page E-30 and are in some cases limited by maximum permissible soil intake rates as indicated. The vegetation-limited application rates shown in Tables II-E-4 and II-E-5 are taken from Table II-E-2 and indicate the maximum wastewater applications permissible for survival of vegetation based on considerations of vegetative cover, soil, slope, growing season and organic loadings. These application rates are estimated as 200 percent of the site requirement of each cover plus its leaching requirement (from Table II-E-7). For example, the annual application rate of 10.2 acre-feet per acre shown in Tables II-E-4 and II-E-5 for the pasture area of Sub-Area 12.1 is the sum of two times the site requirement for vegetation (4.3 acre-feet

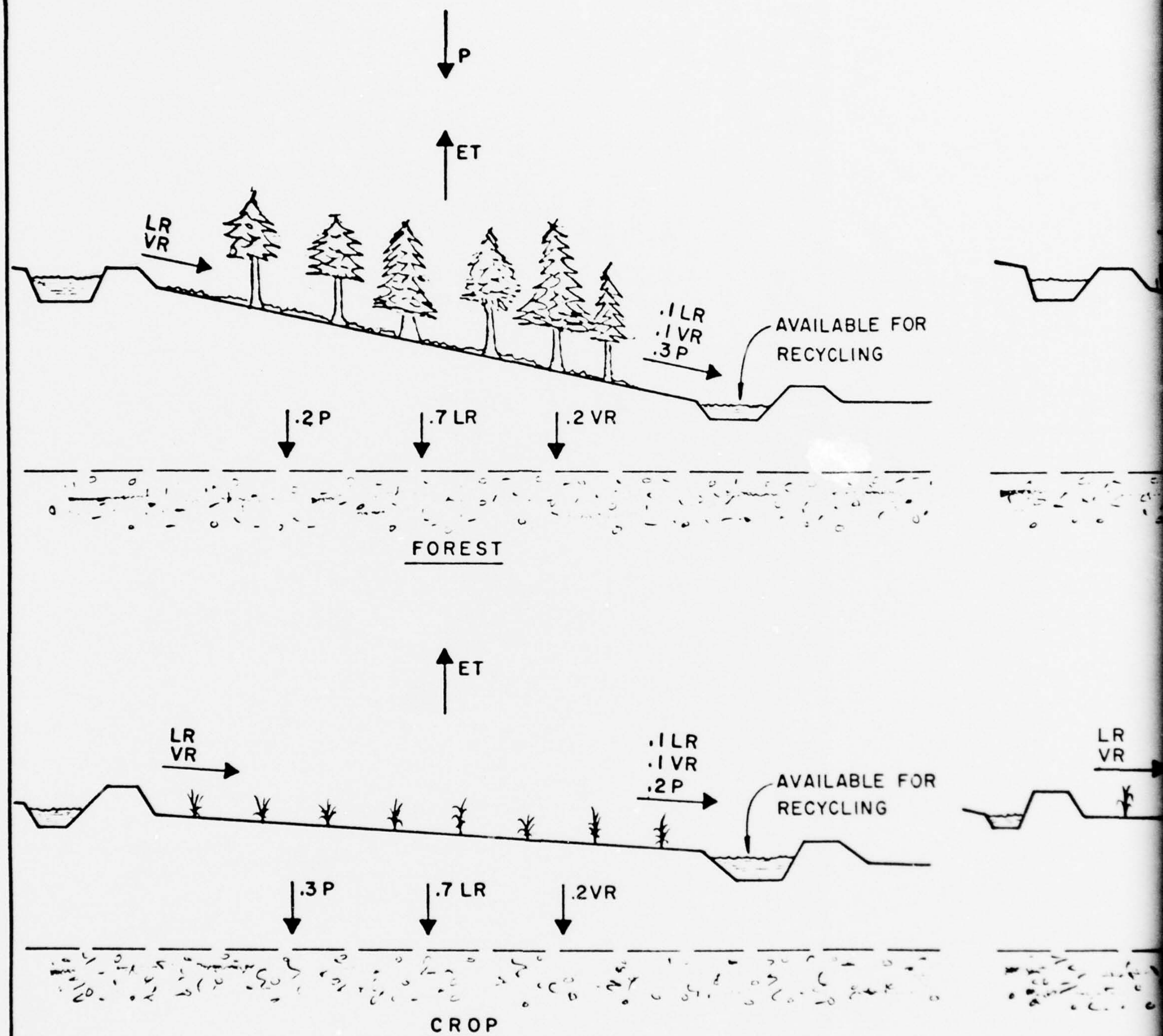
per acre) plus the site leaching requirement (0.6 acre-feet per acre) shown in Table II-E-7. These vegetation-limited application rates are also limited in some cases by maximum permissible soil intake rates as indicated.

7 - Recovery Rates

Any estimate of the complete distribution of water resulting from a water spreading operation on soil covered with vegetation that is subject to the natural variations in climate must at least be based on averages and at best on judgements. Figures II-E-3, II-E-4 and II-E-5 present estimated long-term average water balances that may prevail for each land use alternative.

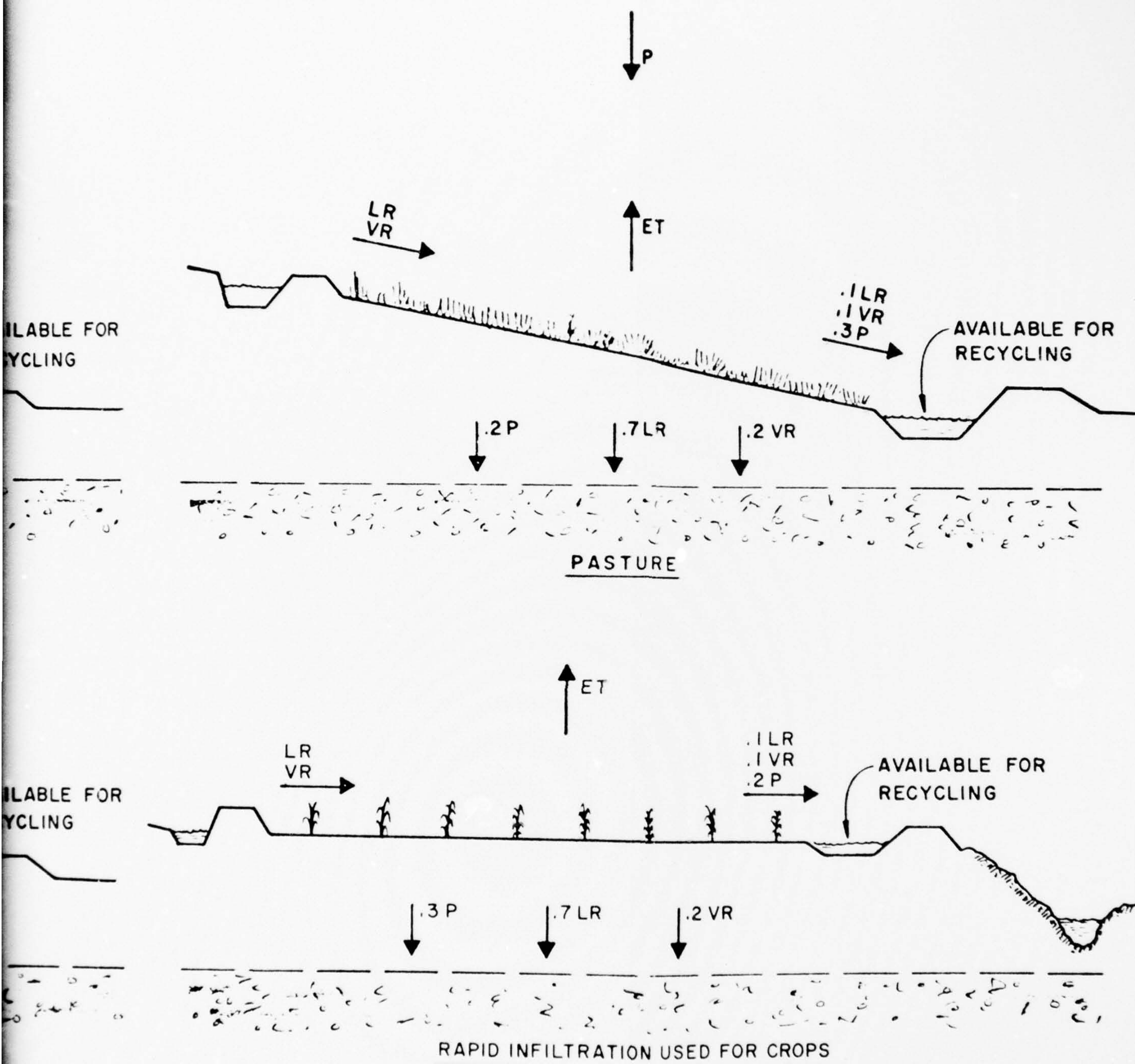
The Corps of Engineers has made long-term rainfall-runoff studies (Ref. 21) of nearly all tributary watersheds in the Sacramento and San Joaquin River Basins. These studies indicate that annual surface runoff varies from 20 to 40% of the annual precipitation with steeper watersheds approaching the upper figure and watersheds in the valley floors approaching the lower figure.

We have, therefore, assumed that for forest and pastures, approximately 30% of the annual precipitation would become surface



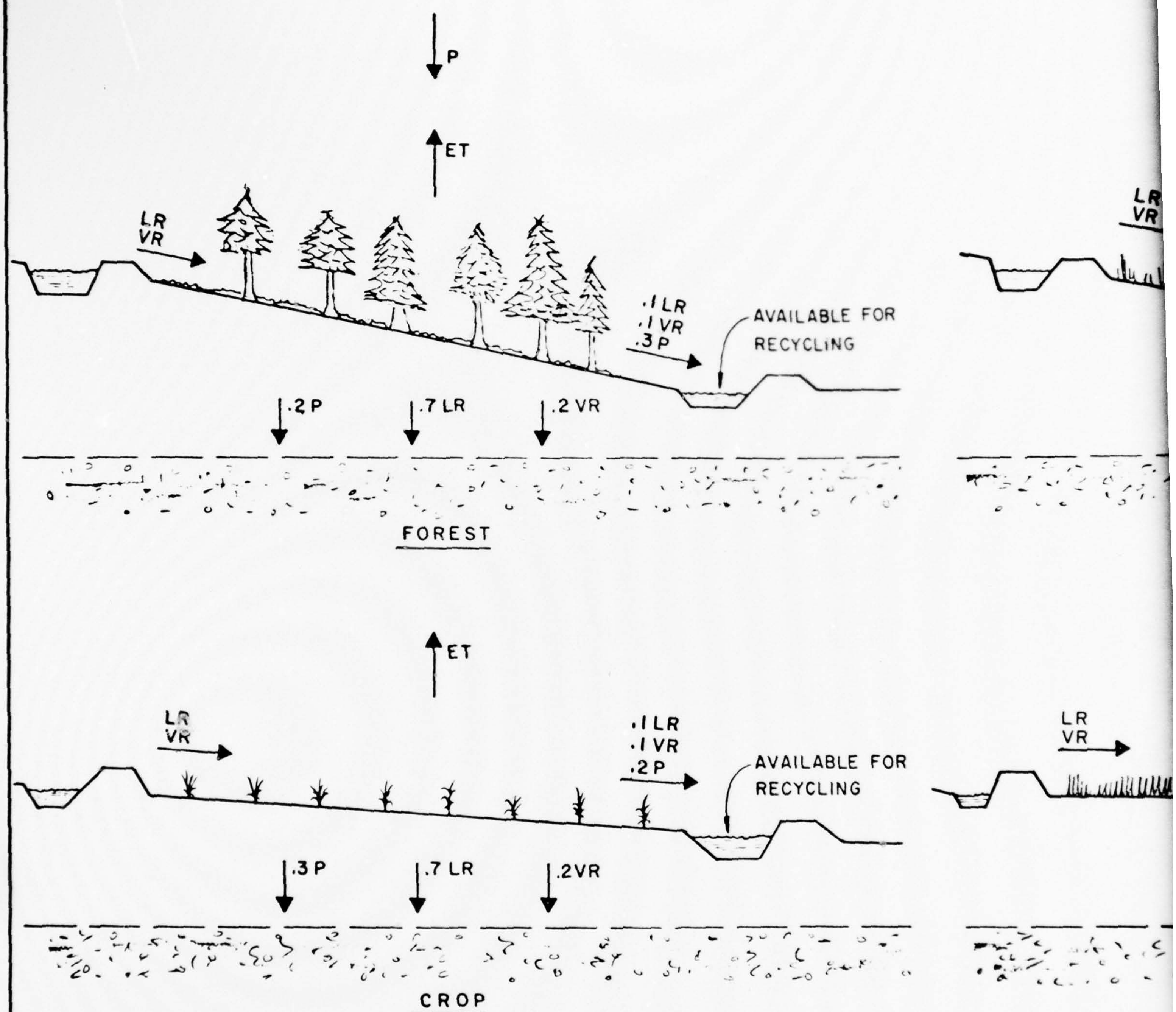
LEGEND

P	PRECIPITATION
ET	EVAPOTRANSPIRATION
LR	SITE REQUIREMENT FOR LEACHING
VR	SITE REQUIREMENT FOR VEGETATION
IA	RAPID INFILTRATION APPLICATION



ALTERNATIVE NO. 1
ESTIMATED WATER BALANCE

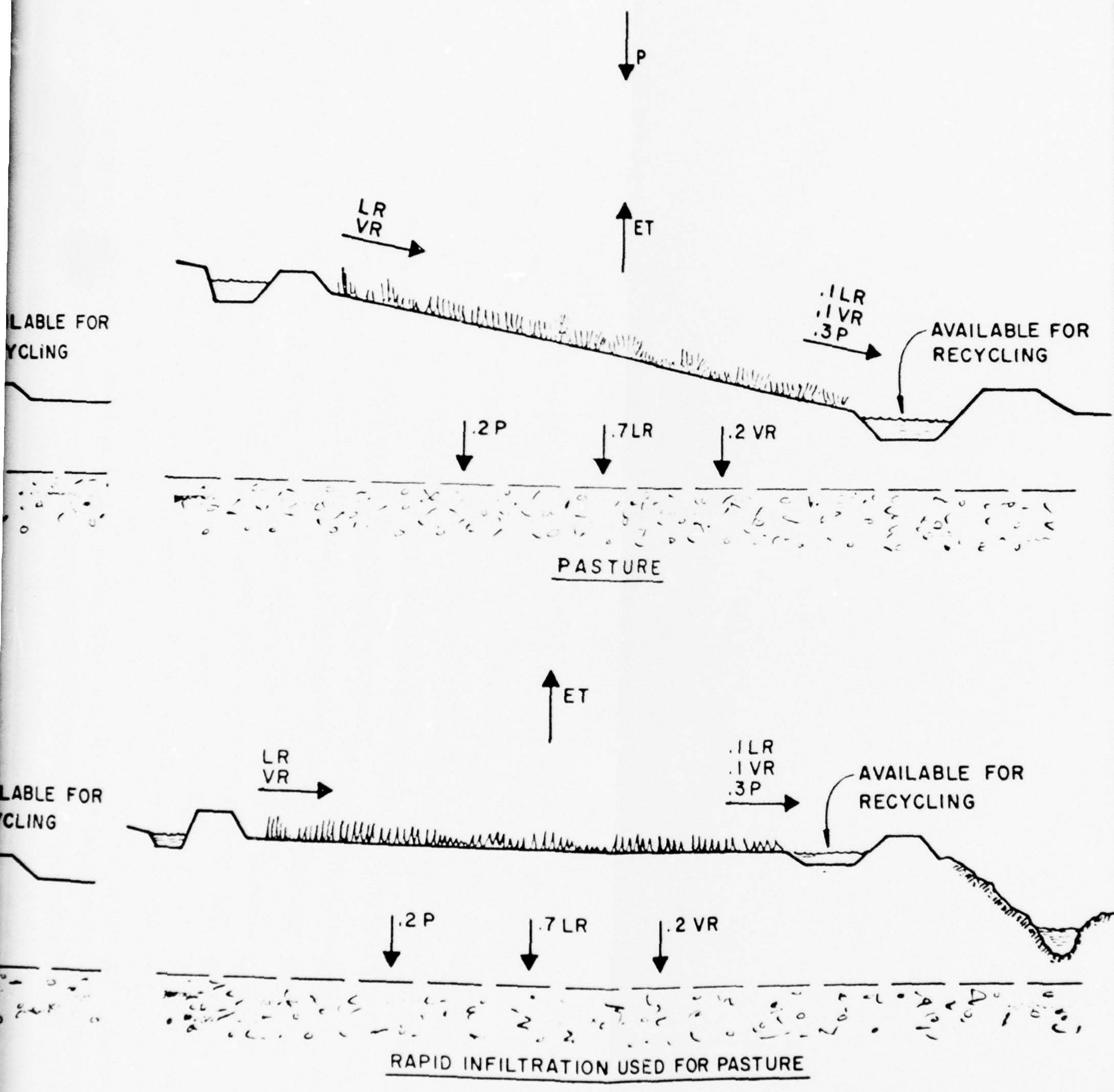
Figure II-E-3



LEGEND

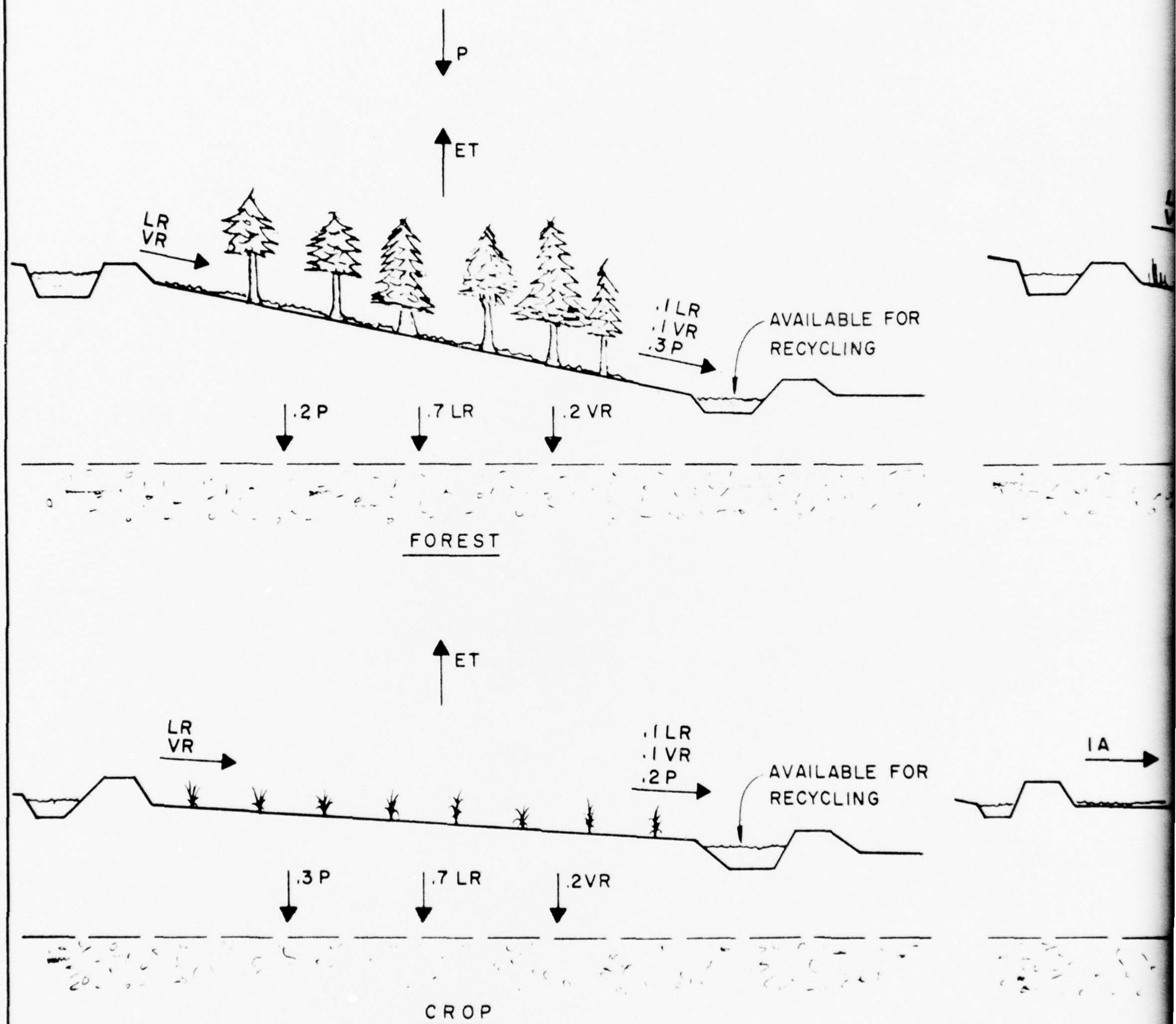
P PRECIPITATION
ET EVAPOTRANSPIRATION
LR SITE REQUIREMENT FOR LEACHING
VR SITE REQUIREMENT FOR VEGETATION
IA RAPID INFILTRATION APPLICATION

PBQ&D, Inc.



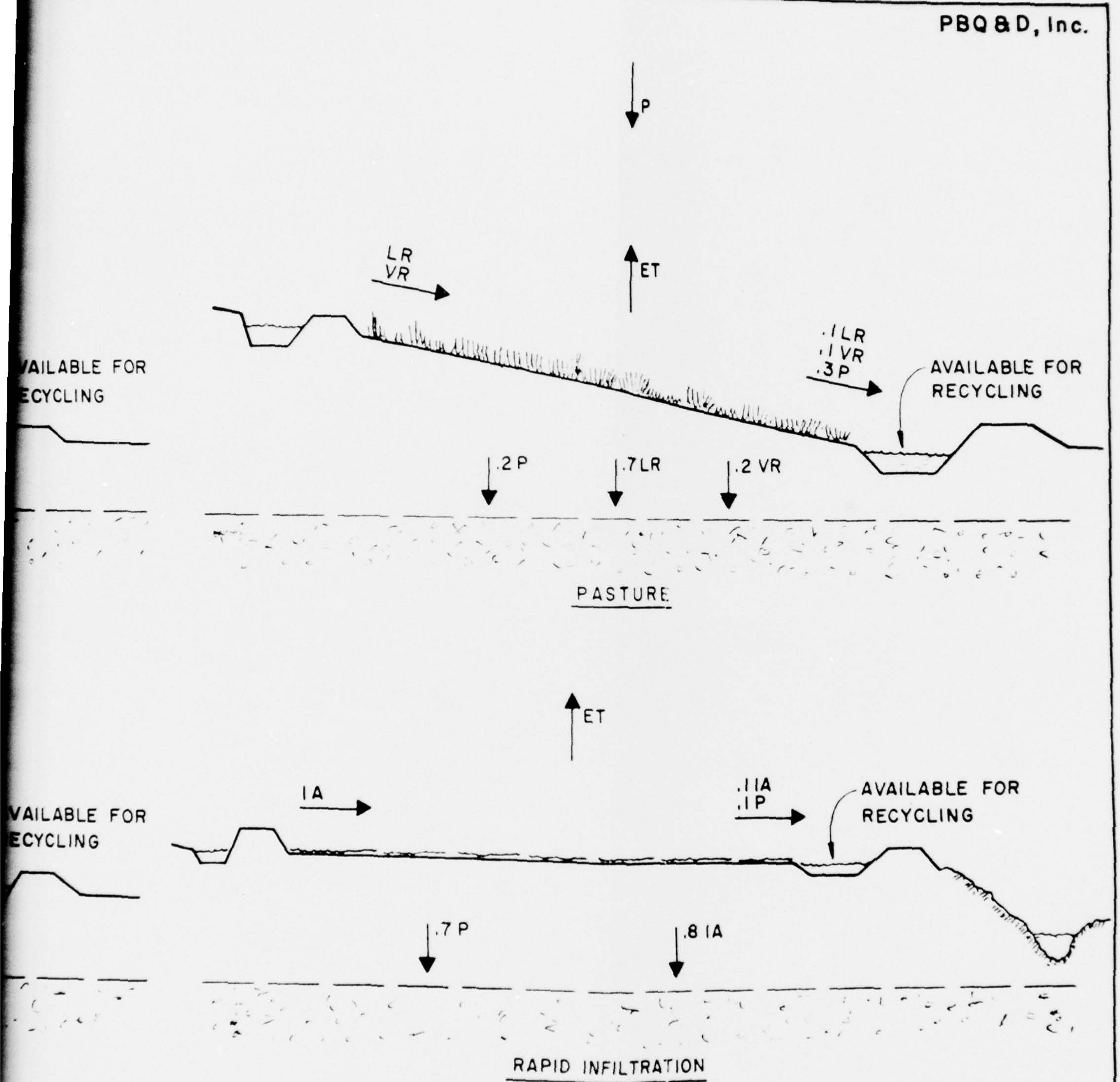
ALTERNATIVE NO. 2
ESTIMATED WATER BALANCE

Figure II-E-4



LEGEND

P	PRECIPITATION
ET	EVAPOTRANSPIRATION
LR	SITE REQUIREMENT FOR LEACHING
VR	SITE REQUIREMENT FOR VEGETATION
IA	RAPID INFILTRATION APPLICATION



ALTERNATIVE NO. 3
ESTIMATED WATER BALANCE

Figure II-E-5

runoff, 20% would infiltrate beyond the root zone and 50% would be used by the vegetation. Because of the flatter slopes for crops and infiltration areas, this distribution of precipitation was weighted toward infiltration.

8 - Treated Water Recovered

Estimates of the annual quantities of treated wastewater recovered by sub-surface drainage or groundwater are shown in Tables II-E-3, II-E-4 and II-E-5. These values are based on the distribution estimates shown in Figures II-E-3, II-E-4 and II-E-5, and assume the use of either closed subsurface drains or properly spaced groundwater wells. Uses for these recovered waters will be dependent on recovery facility locations and on the recovered water qualities.

9 - Recovered Water Quality

Two qualities of recovered water must be considered; that appearing in the surface collector drains and that appearing in the sub-surface drains or the groundwater reservoir where sub-surface drains are not provided. The surface runoff would be recycled to adjacent areas for reuse. In this process it would receive at least as much treatment as the water recovered by the sub-surface drains or the groundwater reservoir. Table II-C-7 gives the average removal efficiencies for each of the wastewater constituents. The variation in the removal efficiency for total nitrogen is discussed in Section C. Table II-E-8 shows estimated recovered water qualities.

10 - Surface Water and Groundwater Quality

An attempt was made to establish the general location and slope of the groundwater tables and the existence of barriers to the vertical and lateral movements of groundwater in the sites. This attempt was not entirely successful because of the almost total lack of well and bore hole data in most of the sites.

Since water well locations are random and confined to areas where groundwater aquifers exist, no meaningful geologic cross sections could be constructed for most sites.

Table II-E-9 gives an estimate of the variation in water qualities found in the selected sites.

Table II-E-8

ESTIMATED QUALITY OF RECOVERED WATER 1/

Wastewater Constituent	Applied Water 2/	Surface Drainage	Sub-Surface Drainage or Groundwater	
			Forest, Pasture and Crops	Rapid Infiltration
Biochemical Oxygen Demand (BOD)	30-60	6-12	0.3-0.6	0.3-0.6
Total Nitrogen (TN)	30-100	6-20	3-20	21-70
Total Phosphorus (TP)	10-20	2-4	1-2	1-2
Total Suspended Solids (TSS)	20-40	4-8	0.2-0.4	0.2-0.4
Total Dissolved Solids (TDS)	400-1000	400-1000 3/	800-2000 4/	450-1100 6/
Phenols	---	---	---	---
Gross Heavy Metals (GHM)	1-20	1-16	0-1 5/	0-1
Oil and Grease	5-15	0.3-0.8	0.3-0.8	0.3-0.8
Coliform and Bacteria	---	---	---	---

NOTES:

1/ Based on Table II-C-7

2/ See Table II-B-10

3/ Water would be recycled to adjacent lands for further treatment.

4/ Assumes one-half of the total application is used for evaporation and transpiration. Sub-surface drains are assumed to receive all applied salts.

5/ May be 30% higher depending on the effectiveness of the salt leaching applications in removing heavy metals.

6/ Assumes 10 percent of water is used.

Table II-E-9

APPROXIMATED GROUNDWATER AND SURFACE WATER QUALITIES

SITE	GROUNDWATER								
	Characteristic (mg/l)					%	Characteristic		
	TDS	Cl^-	$SO_4^=$	TH 2/	B	Na	TDS	TH 2/	TNCH
4	970	132	---	319	1.2	45	110-340	---	---
5	328	45	12	138	0.2	38	117-633	83-355	0-266
12	282	35	11	115	-0-	38	67-3550	28-1240	0-108
18	127-560	5-124	3-60	35-294	0-2.0	19-83	110-340	40-232	0-61
21	300	48	6	64	0.9	74	51-226	40-232	0-61
27	550-770	88	133-239	324-540	0.2-0.8	35	180-1090	132-650	0-263
28	---	---	---	---	---	---	340-700	---	---
42	548	58	28	110	0.5	43	52-1280	26-503	0-347
43	548	58	28	110	0.5	43	340-700	36-142	0-37

NOTES:

1/ From Quality of Surface Waters of the United States, Geological Survey Water-Supply Paper, 1965, Region, California Region Framework Study Committee for the Pacific Southwest Inter-Agency Comm

2/ Total Hardness

3/ Total Non-Carbonate Hardness

Table II-E-9

ROUNDWATER AND SURFACE WATER QUALITIES 1/

		SURFACE WATER									
	%	Characteristic (mg/l)				%	Dominant Ions				
3	Na	TDS	TH 2/	TNCH 3/	B	Na	Ca^{++}	Mg^{++}	$SO_4^{=}$	Cl^-	HCO_3^-
.2	45	110-340	---	---	---	---	x	x			x
.2	38	117-633	83-355	0-266	.15-5.0	16-42	x	x			x
)-	38	67-3550	28-1240	0-1080	0-1.5	34-63				x	
.0	19-83	110-340	40-232	0-61	0-3.0	11-23	x	x			x
.9	74	51-226	40-232	0-61	0-3.0	11-23					
-0.8	35	180-1090	132-650	0-263	0-0.7	19-56	x	x			x
-	---	340-700	---	---	---	---	x	x			x
5	43	52-1280	26-503	0-347	0-0.8	32-58	x	x		x	x
5	43	340-700	36-142	0-37	0-0.2	---	x	x	x	x	

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Geological Survey Water-Supply Paper, 1965, and Comprehensive Framework Study - California for the Pacific Southwest Inter-Agency Committee Water Resources Council, 1971.

11 - Site 4 Evaluation

Site 4 was selected to represent the opportunity for enhancing a wildlife habitat and, due to the limited potential for agricultural applications based on distinct soil characteristics and the desire to provide food for waterfowl, Site 4 was not evaluated in the same manner as were the other eight selected sites. Soil association data, potential vegetative covers and wastewater applications for Site 4 are indicated in Tables II-E-10 and II-E-11.

12 - Projected Life of Sites

The magnitude and frequency of wastewater applications and the drainage systems recommended for all sites are selected to allow permanent operation. Nitrogen forms, phosphates, phenols and the soluble salt fractions will either be continuously used by the vegetation, volatilized, biodegraded or leached from the soil profile.

Nearly all phenols and gross heavy metals are from industrial wastes and, at high concentrations, are potentially toxic to plants, animals and humans. The gross heavy metals are expected to accumulate in the soil profile in proportion to its clay content with little plant uptake or leaching occurring. Hence, gross heavy metals (and phenols) must be removed from the industrial wastes at their sources. With this restriction continuous annual operation of all sites can be achieved.

Table II-E-10

POTENTIAL VEGETATIVE COVERS FOR SITE 4

Site Sub-Area No.	SOIL ASSOCIATION CHARACTERISTICS				POTENTIAL VEGETATIVE COVERS & AREAS					Excluded Area (1000 acres)	Total Net Area (1000 acres)
	Name	Gross Area (1000 acres)	Capability Class 1/	Present Use 2/	Waterfowl Vegetation 3/	CROPPED AREAS					
						Alfalfa	Grain	Truck, Field & Row	Total Crops		
4.1	Valdez	0.4	III	DC	---	---	0.1	0.2	0.3	0.1	0.3
	Reyes-Tamba	2.0	VI	P,W	1.9	---	---	---	---	0.1	1.9
	Suisun-Joice	3.2	VI	P,W	3.1	---	---	---	---	0.1	3.1
Total		5.6	---	---	5.0	---	0.1	0.2	0.3	0.3	5.3
4.2	Valdez	3.9	III	DC	---	0.5	1.0	2.2	3.7	0.2	3.7
	Suisun-Joice	2.7	VI	P,W	2.6	---	---	---	---	0.1	2.6
Total		6.6	---	---	2.6	0.5	1.0	2.2	3.7	0.3	6.3
Grand Total		12.2	---	---	7.6	0.5	1.1	2.4	4.0	0.6	11.6

NOTES:

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1/ For definitions of capability classes, see Table II-C-2.
2/ For definitions of present uses, see Table II-E-2.
3/ Areas would be devoted to improving natural vegetation such as Alkali Bulrush.

Table II-E-11

WASTEWATER APPLICATION FOR SITE 4

Site Sub-Area No.	Waterfowl Areas		Cropped Areas		Total Net Area (1000 acres)	Total Annual Application (1000 acre feet)
	Net Area (1000 acres)	Unit Application Rate (acre-feet per acre)	Net Area (1000 acres)	Unit Application Rate (acre-feet per acre)		
4.1	5.0	5.0	0.3	5.0	5.3	26.8
4.2	2.6	4.8	3.7	3.9	6.3	26.9
Total	7.6	---	4.0	---	11.6	53.7

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F. SITE DEVELOPMENT

F. SITE DEVELOPMENT

The development of wastewater distribution, application and drainage systems will require a detailed design effort. Considerable site field data such as detailed topography (a scale of 1:5,000), detailed soil classification, land use and ownership identification, site infiltration and seepage tests and comprehensive hydrologic and hydraulic analyses will be necessary to support this design effort.

1 - Application and Recovery Systems

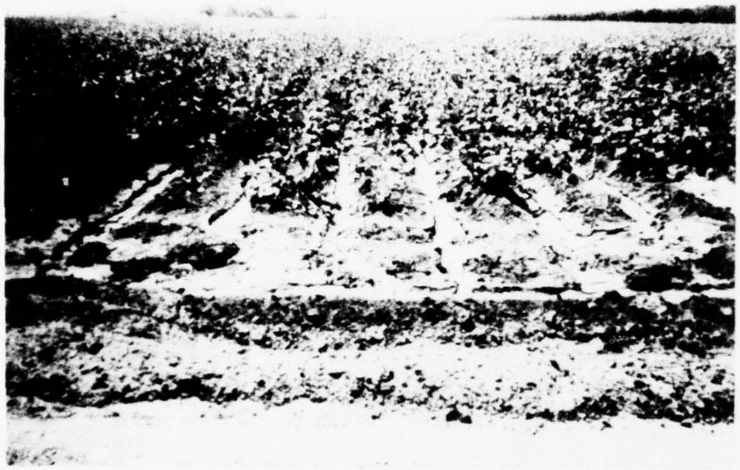
General methods of wastewater distribution to land parcels include the utilization of open ditches, buried pipe laterals and combined systems. Land parcels will vary in size depending on topography, ownership, proposed land use and method of application of wastewater. Open ditches have been used extensively in the West for irrigation purposes and may be satisfactory in selected areas of proposed wastewater sites. In recent years, an increased concern for water conservation, public safety, appearance and reduced maintenance has initiated a shift from open ditch laterals to buried pipe laterals. The U. S. Bureau of Reclamation now has a policy of using buried pipe systems unless specific justification for an open ditch system can be found.

Proposed wastewater application designs will utilize surface irrigation and sprinkler systems. Surface irrigation systems can be designed for a minimum of operation and maintenance but require nearly level land or contour or terraced irrigation and are therefore suitable for use in selected site areas only. Sprinkler systems can be used on nearly any of the terrain under consideration and allow careful control of wastewater application. Initial costs are normally higher and evaporative losses are greater; however, returning the water to a natural cycle through evaporation may be considered a benefit.

Site drainage system designs will incorporate open surface drains, closed sub-surface drains and wells. The choice of specific drainage systems for land parcels will depend on topography, soil and subsoil conditions, vegetative cover, groundwater levels and water quality protection requirements.

Figures II-F-1 through II-F-4 show a range of actual installations of distribution and drainage facilities for operating irrigation systems. These irrigation facilities are representative of the facilities that could be utilized in developing the wastewater application sites. In contrast

Figure [illegible]



Tail Water Ditch and Furrows With Crops

Tail Water Ditch (Filled)

Recycling for Tail Water

Tail Water Recovery and Recycli

Figure F-1

Tail Water Ditch (Filled)

Tail Water Sump for Surface Irrigation

Tail Water Recovery and Recycling

Deep Surface Drain

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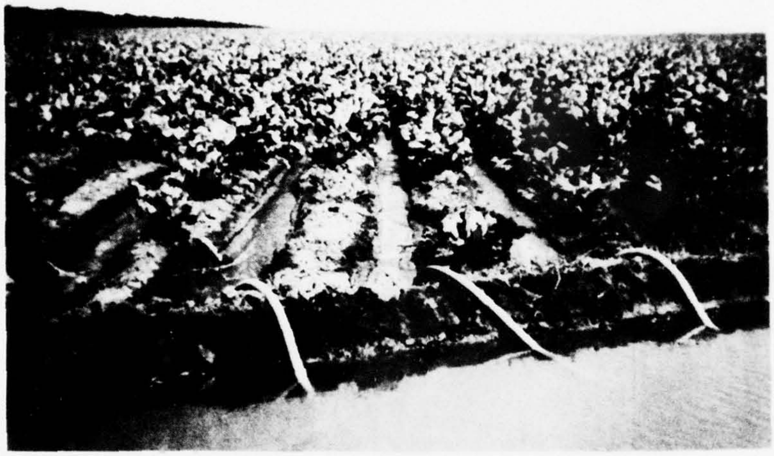
Figure II-F-2



Furrow Irrigation With Siphon Tubes

Basi

Head Ditch Supplied by Ground Water Pump

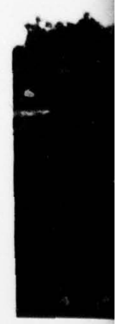


Figure II-F-2

pes

Basin Irrigation for Pasture

Vinyard Irrigation by Portable Sprinkler

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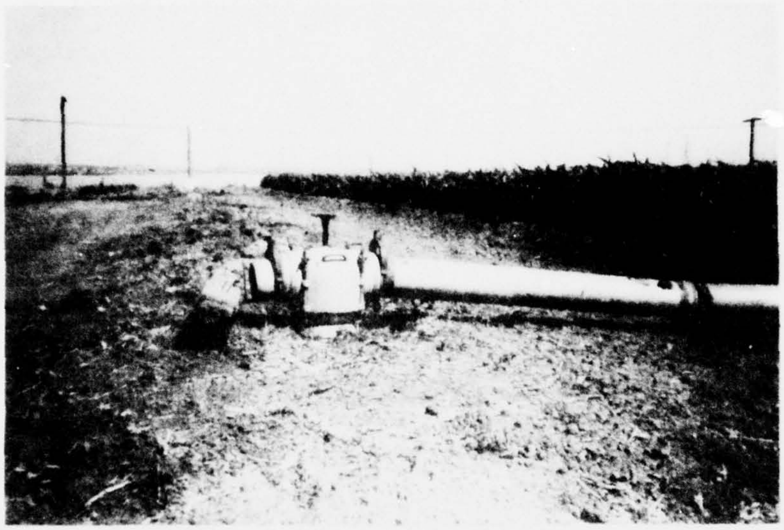
Figure II-F-3

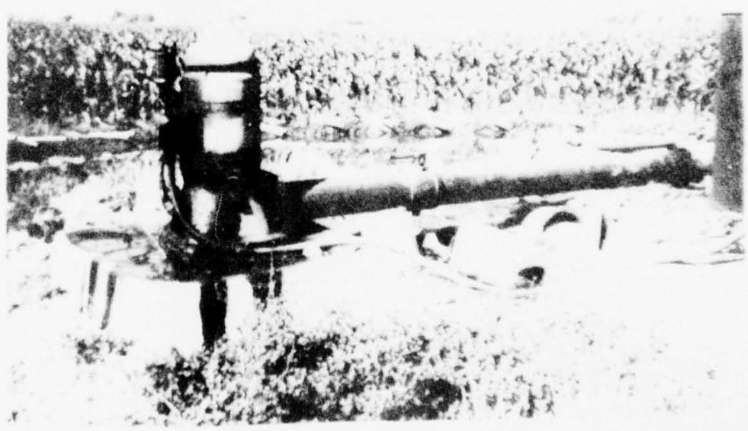


Hydrant Attached to Alfalfa Valve for Gated Pipe

Gated Pipe Irrigation for Corn Fod

Figure II-F-3

Gated Pipe Irrigation for Corn Fodder



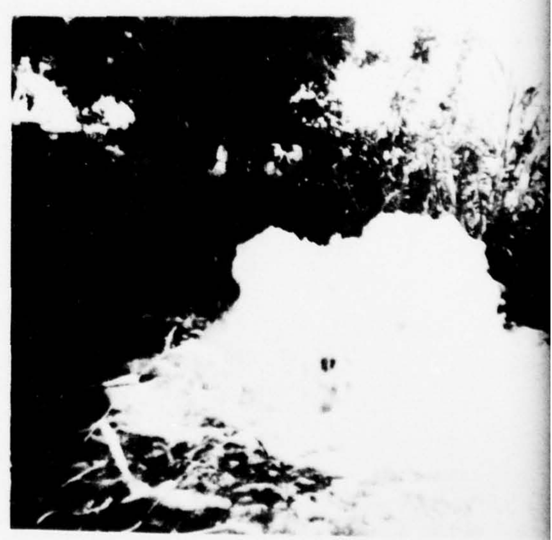
Electric Driven Pump

Figure II-F-4

Delta Mendota Canal

Farm Head Ditch With Che

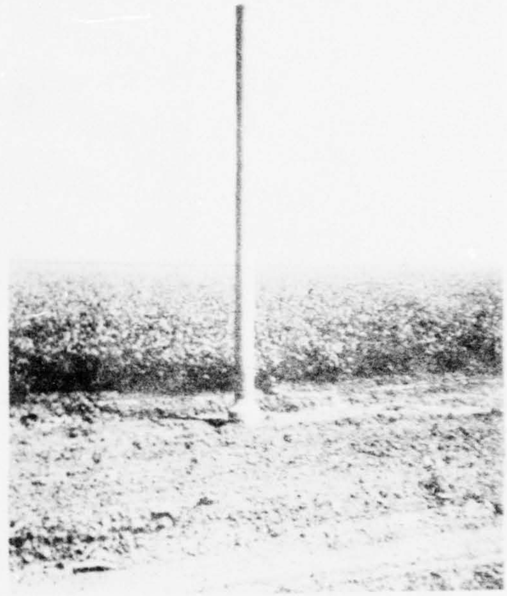
Alfalfa Valve Mounted on Concrete Pipe (not flowing)



Alfalfa Valve Mounted on Concrete Pi

Figure II-F-4

Farm Head Ditch With Checks



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Alfalfa Valve Mounted on Concrete Pipe (flowing)

[illegible]

to the high surface runoff shown in Figure II-F-1, wastewater projects would be designed and managed to achieve a minimum of surface wastes. Also, public access to surface storage and unavoidable surface waste would be restricted by fencing.

Figure II-F-5 shows some of the facilities operated by the City of Pleasanton, California. Of particular note here are the undesirable species of grasses and weeds (thistle, bunch grasses, etc.) which are present and can only be controlled by spraying, reseeding or lower and more frequent water applications. These lower rates will allow the more desirable grasses to remain dominant.

The present annual rate of wastewater application at the Pleasanton site is approximately nine feet per year. It is, however, applied at a rate of nearly one foot per 12-hour period with a rotation of about one month. Hence the grasses suffer from lack of available moisture before the next application and are weakened allowing the more drought resistant plants to dominate after several years of operation.

The Pleasanton operation appears to be quite successful overall and provides a good demonstration of land application of wastewater on a small scale.

2 - A Typical Site Development

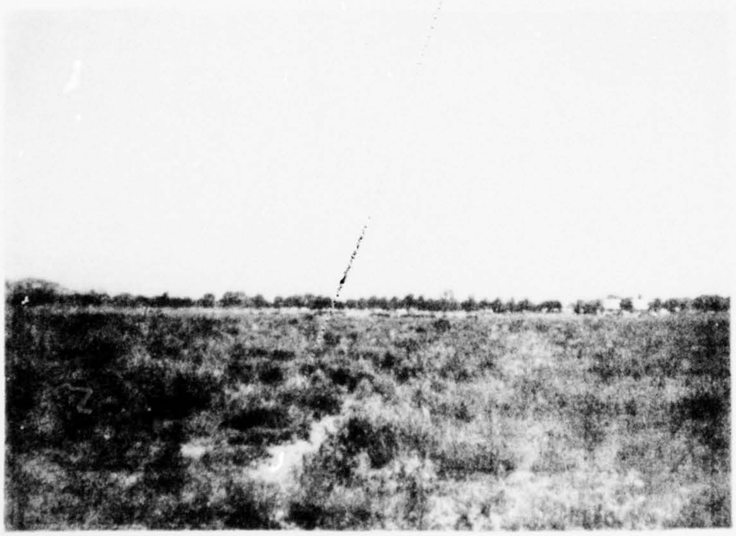
Development of comprehensive site systems for the conveyance, distribution, application and recovery of wastewaters must be based on careful analysis of individual site characteristics. The specific design requirements of a particular site are primarily dictated by site topography although many other factors are involved. The discussion that follows outlines a typical approach to the design of a distribution, application and recovery system for Site Sub-Area 5.1. This approach is not intended as a guide for the design of the conveyance, storage, application and drainage systems for the site, but is rather a discussion of many of the considerations that will be involved in the design of these systems for any site. It does illustrate typical problems that will be encountered and emphasizes the need for a comprehensive and imaginative approach.

Located in the inner coast range mountains, Sub-Area 5.1 encompasses the Capay Valley in Yolo County. This valley contains both irrigated and dryland agricultural areas in the central basin, some grassland areas in the lower elevations, and hardwood forests and chaparral-mountain brush lands in the higher and steeper areas of the western and eastern ridges (see Figures II-F-1, page F-8; II-E-2, page E-18; and

Figure II-F-5

Secondary Influent to Holding Ponds (Pleasanton)

Aerated Holding Pond (Pleasanton)



Pasture Grasses of Application Area (Pleasanton)

10% Slope of Portion of Pasture Area (Pleasanton)

Figure II-F-5

Aerated Holding Pond (Pleasanton)

Pasture Grasses of Application Area

Note: Non-uniformity of grass species (Pleasanton)

Slope of [illegible] of Pasture Area [illegible]

[illegible] Area [illegible]

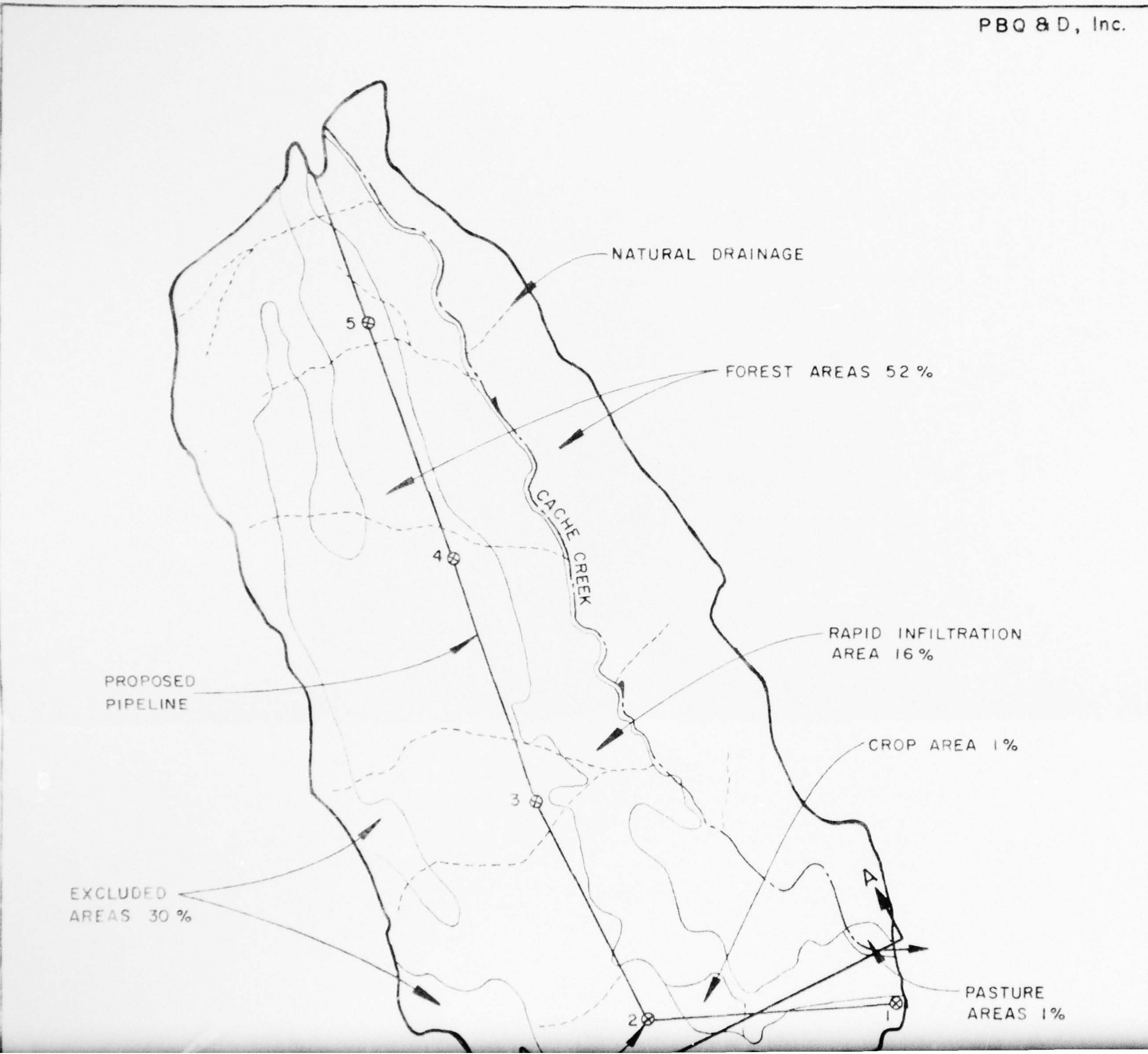
II-F-6). Cache Creek runs the length of the basin from north to south, from an elevation of about 440 feet at the north end to about 230 feet at the south end. The overall length of the site is approximately 16 miles, and valley width varies from about 5.5 to 7.5 miles. The gross area of the site is 67,100 acres, with 46,700 acres considered suitable for wastewater application. Included in the net area are 11,000 acres of Yolo-Brentwood soil located in the central basin area to the west of Cache Creek, which are proposed for utilization as a maximum infiltration area under Alternative 3 (see Table II-E-5). The remaining area extends up the western and eastern valley slopes to maximum elevations of about 1500 feet and is suitable for forest, pasture and crop lands.

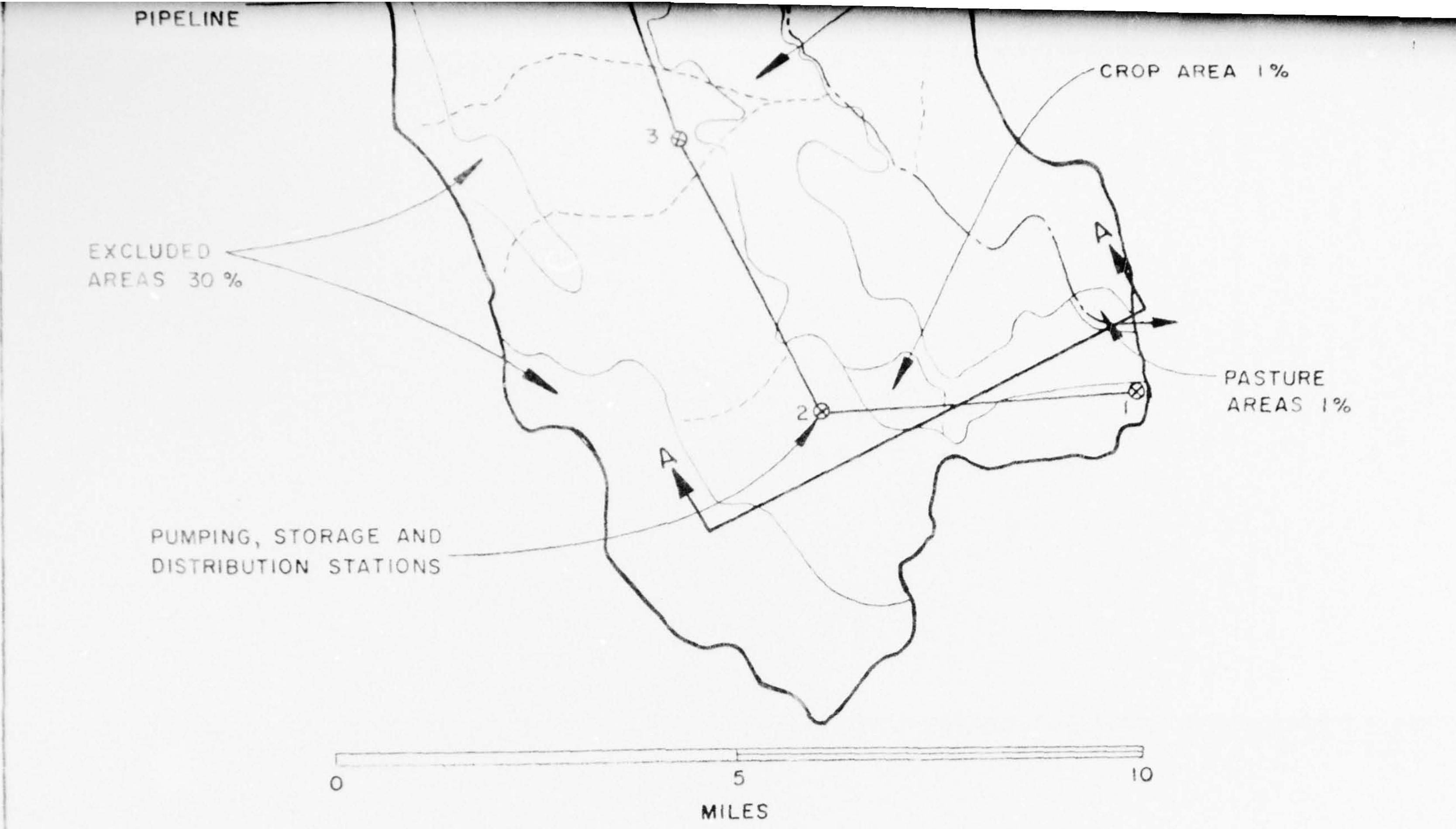
The sub-are exhibits varied topography and soil types and illustrates the design problem of devising a system to meet the requirements of landscapes ranging from flat alluvial fans to steep forested areas. The location of Cache Creek (a California Protected Waterways Plan Class II stream) in the middle of the basin introduces the problems of locating the site systems for protection and possible enhancement of existing environmental values.

It is assumed that the potential supply of wastewater for this sub-area will be the Sacramento area, which is the nearest major metropolitan area and is approximately 40 miles southeast of the basin; thus the most probably wastewater inflow point is at the south (downstream) end of the basin. Location of the source at a low point in this area introduces a typical problem of distribution system design which will be encountered in other sites.

This particular sub-area, with relatively steep sideslopes (up to about 35-40%) along the western and eastern slopes, a pumping requirement of about 1000-1300 feet above the source point for the higher lands on these slopes, and a central valley portion of flat, open lands, may best be served by a multipel system and/or a combination of conveyance, application and reclamation designs: open channels and conduits for conveyance, irrigation ditches and sprinklers for application and surface and sub-surface drains and wells for drainage.

Identification of land uses for specific areas must precede extensive design work since application requirements for rapid infiltration areas under Alternative 3 are 10 to 20 times the application requirements for forest, pasture or crop areas. It is possible that some of the potential rapid infiltration areas may be considered more valuable in other land uses such as are indicated in Alternatives 1 and 2; this decision must preclude any design work. For purposes of this discussion, however,


NATURAL DRAINAGE
FOREST AREAS 52 %
CACHE CREEK
RAPID INFILTRATION
AREA 16 %
CROP AREA 1%
PROPOSED
PIPELINE
EXCLUDED
AREAS 30 %
PASTURE
AREAS 1%
A
1
2
3
4
5



TYPICAL WASTEWATER APPLICATION DEVELOPMENT

SUB-AREA 5.1 (Capay Valley)

Figure II-F-6

it will be assumed that all potential rapid-infiltration areas will be utilized to capacity, thereby creating maximum flow requirements and ensuring an adequate system design.

Consideration should also be given to possible locations for wastewater storage facilities within the site in addition to any major facilities proposed for storage capacity for the site. It is assumed that any proposed major reservoir will be located outside the basin area for Sub-Area 5.1, and probably to the south, but it should be noted that alternate placement (possibly within the site or at the higher end of the basin) could have a pronounced effect on design requirements for the site. Strategic placement of smaller reservoirs within the site could utilize potential natural storage areas and reduce hydraulic requirements; in addition, these facilities could be designed and operated to provide pond-settling capabilities.

Preliminary investigation of Sub-Area 5.1 indicate that there are several potential reservoir sites in the canyons along the western slope of the valley, but in-depth geologic investigation must precede determination of technical feasibility. Likewise, portions of the western and eastern slopes of the basin appear to be suitable for surface irrigation, while other areas on the slopes are too rugged to permit uniform and efficient application by surface irrigation and would require movable sprinkler systems.

In this consideration of the system design problem for Sub-Area 5.1, it is assumed that any major storage facility for the area will be located at the south end of the basin, that all potential areas will be utilized for maximum wastewater application under Alternative 3 and that application rates will be about five feet of wastewater per year to the forest, pasture, and crop lands for 8 months of the year, and 90 feet per year to the Yolo-Brentwood acreage intended for rapid-infiltration utilization on a year-round basis.

Any system proposed for Sub-Area 5.1 will have to provide for pumping of the water along the valley floor, as ground slopes along Cache Creek prevent the use of an open channel. Two basic overall design approaches appear to be the most feasible:

1) Pumping of the water from the southern point in the basin through three separate distribution systems: one each for the eastern and western forest, pasture and crop land areas and one for the rapid-infiltration acreage located in the central valley portion.

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THE SAN FRANCISCO BAY - DELTA WASTEWATER AND RESIDUAL SOLIDS MA--ETC(U)
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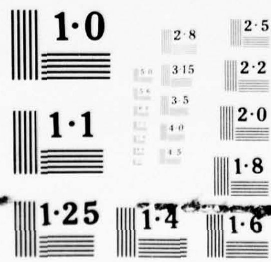


This plan would require pumping of wastewater to the eastern and western ridges of the basin, at heights of 800 to 1200 feet above the southerly supply point. Additionally, a pipeline would be required for distribution of wastewater for the rapid-infiltration acreage in the Central Valley Region. The lift for pumping to the eastern and western slopes is great, but it should be noted that flows to the eastern and western slopes comprise only about 20-25% of the total flow requirement for the basin.

A system of open channels along the eastern and western ridges has been considered in combination with gravity-fed surface irrigation systems, but the topography indicates that construction of such channels, which would be 2 to 5 times the length of the valley if natural contour elevations are followed, would be tedious and costly. One alternative is the construction of pipelines along the ridges at the most feasible and convenient elevations for supplying wastewater to the irrigation and sprinkling systems at lower elevations.

Under this plan, a pipeline located in the central valley floor would be required to provide wastewater to the Yolo-Brentwood rapid-infiltration area, and a series of pumping and outlet stations would be required along this central pipeline. The construction of levees in this rapid-infiltration area may permit the utilization of gravity-assisted wastewater application.

It should be noted that no conveyance of wastewater across Cache Creek would be required under this plan.

2) Pumping of the entire quantity of required water through a pipeline located just upslope (west) from the Yolo-Brentwood acreage.

An obvious economy would be gained by pumping the wastewater into one pipeline rather than three, but larger pumping stations would be required along this central pipeline to handle the flows to the eastern and western slopes as well as the application requirement for the rapid-infiltration area. This system could be devised to include a minimum number of pumping stations and other costly hardware, as distribution points along the central pipeline could supply all three areas at once; the western slope, the central rapid-infiltration area, and the eastern slope (see Figure II-F-6). This plan, on the other hand, must provide for conveying wastewater across Cache Creek, which reaches a maximum width of about 200-400 feet, to the eastern slope of the basin.

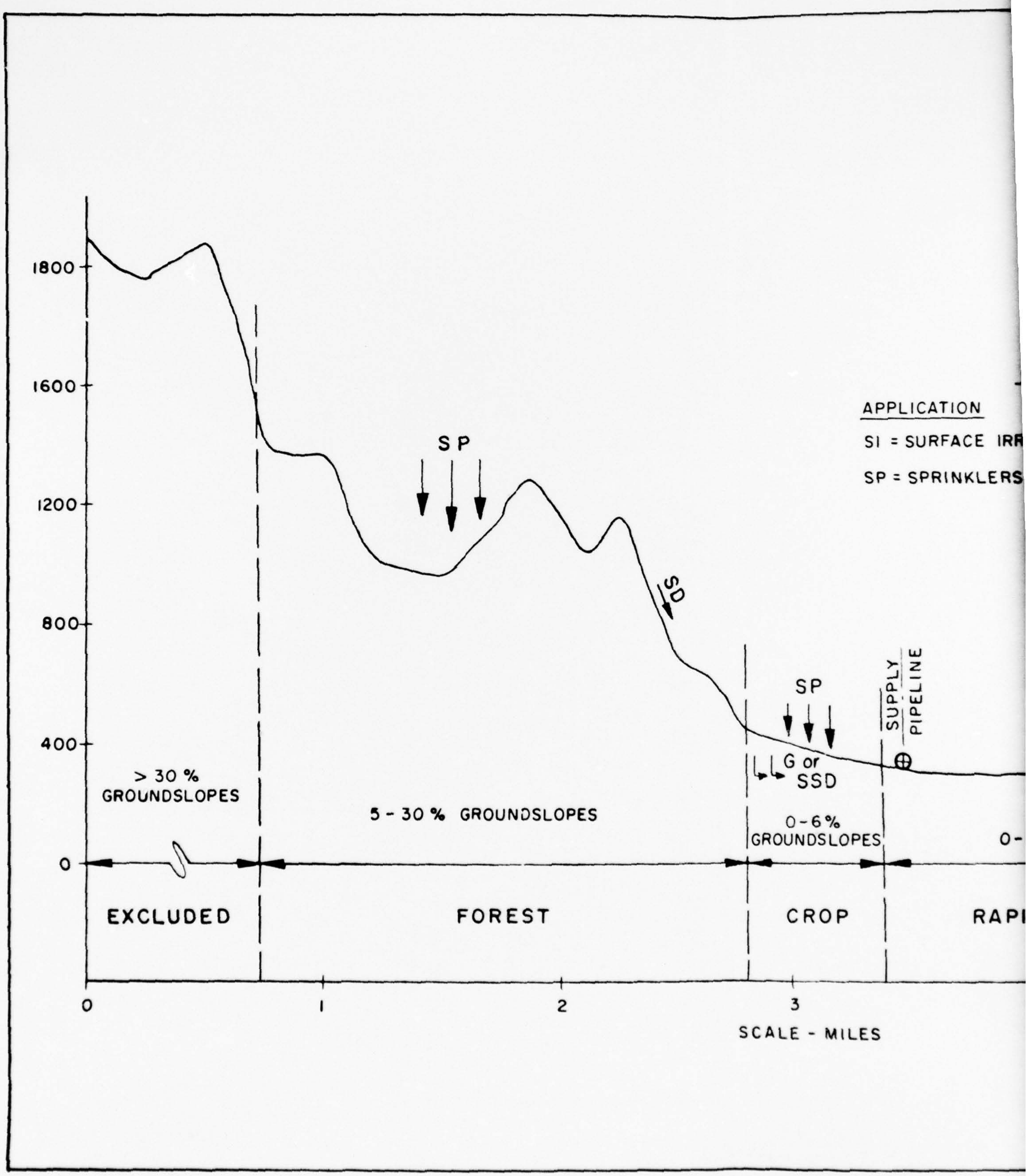
Under this plan, a moveable sprinkling system would be constructed to provide maximum efficiency and uniformity in the distribution of wastewater to the forest, pasture, and crop areas suitable for sprinkler application, and surface irrigation may be incorporated by pumping of the wastewater from the central pipeline into channels in areas of suitable topography. Spreading on the rapid-infiltration area may again be achieved by gravity-feeding to sections defined by a system of levees.

Each of the two plans for Sub-Area 5.1 calls for a central pipeline to be constructed just upslope from the rapid-infiltration area. A series of pumping and storage stations would be required at convenient locations and at suitable intervals along the pipeline. The sizes of storage and pumping facilities would be determined from application and flow requirements, with reservoirs providing storage capacities sufficient to allow for continuous pumping along the pipeline, thereby significantly reducing sizes and costs of pipeline and pumping equipment.

Preliminary flow requirement calculations have been made for a system of five pumping, storage and distribution stations located along a proposed central pipeline (see Figure II-F-6). Estimates indicate that continuous flows in the five sections of pipeline will range from about 1800 cfs in the initial section to about 300 cfs in the last section. Storage capacity requirements for these facilities would be calculated from flow estimates and system flexibility requirements. Each of the five stations would have outlets for the distribution of wastewater to adjacent forest, pasture, crop and rapid-infiltration areas. Additional pumps would be required at these stations to serve areas in which topography cannot provide the hydraulic head required for distribution, and pipelines crossing Cache Creek would be required for the transporting of wastewater to eastern slope areas. These pipes could incorporate outlets for the distribution of wastewater to the rapid-infiltration areas.

A typical sprinkler system for suitable areas might include moveable surface sub-lateral lines supplied from a network of buried main laterals receiving flow from the five storage and pumping stations. Areas suitable for surface irrigation could be supplied by open ditches receiving wastewater directly from the pumping stations. The design of sprinkler and irrigation systems would incorporate natural surface characteristics and slopes to facilitate east in construction and operation.

Figures II-F-7 and II-F-8 illustrate a possible scheme of wastewater distribution and drainage systems. Areas with steep slopes will best be served by sprinklers and surface drainage systems, and some flatter areas may more effectively utilize surface irrigation and sub-surface drainage systems. Natural drainage patterns in the sub-area are extensive



APPLICATION
SI = SURFACE IRR
SP = SPRINKLERS
SP
SD
SP
G or SSD
SUPPLY PIPELINE
1800
1600
1200
800
400
0
> 30 % GROUNDSLOPES
5 - 30 % GROUNDSLOPES
0 - 6 % GROUNDSLOPES
0 -
EXCLUDED
FOREST
CROP
RAPI
0
1
2
3
SCALE - MILES

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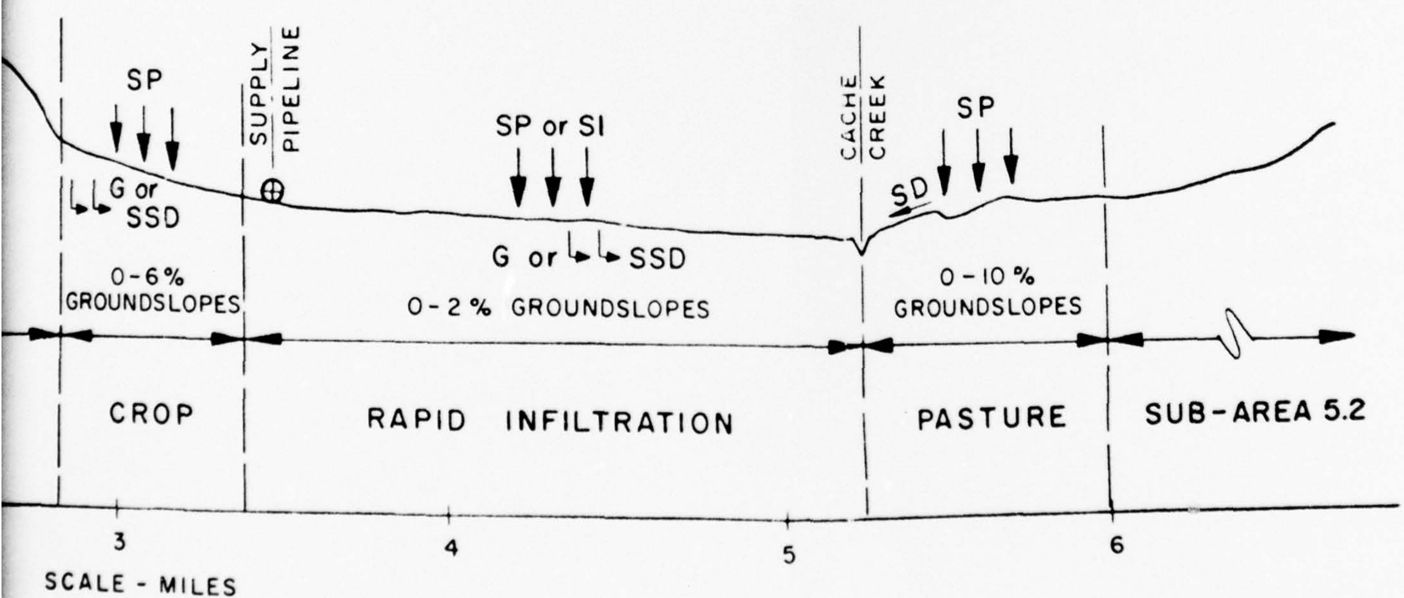
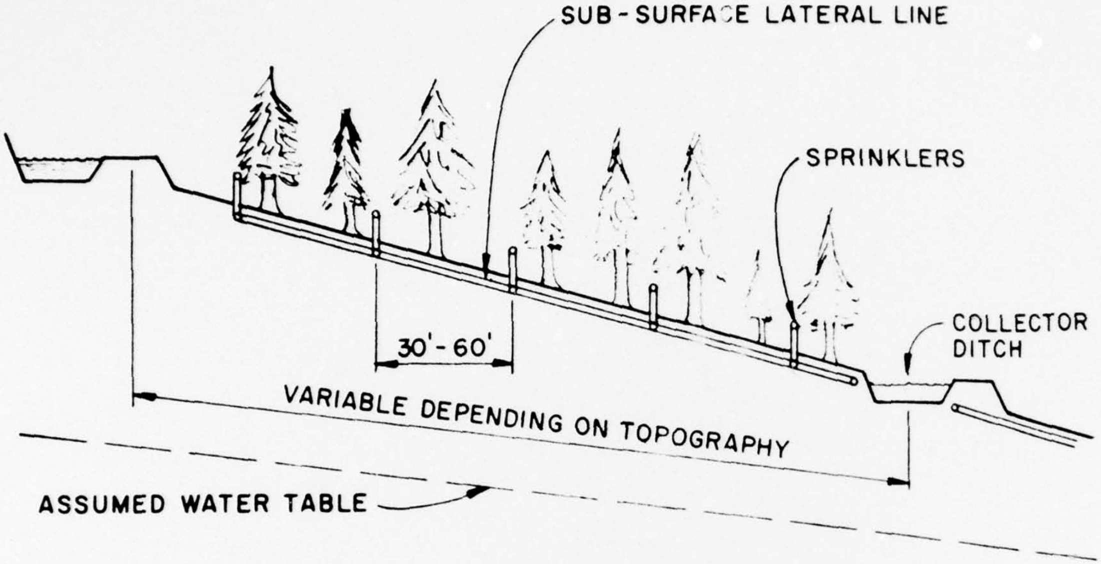
SECTION A - PROFILE AND POTENTIAL SYSTEMS LAYOUT

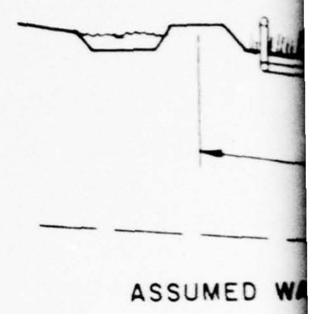
Figure II - F - 7

SYSTEMS

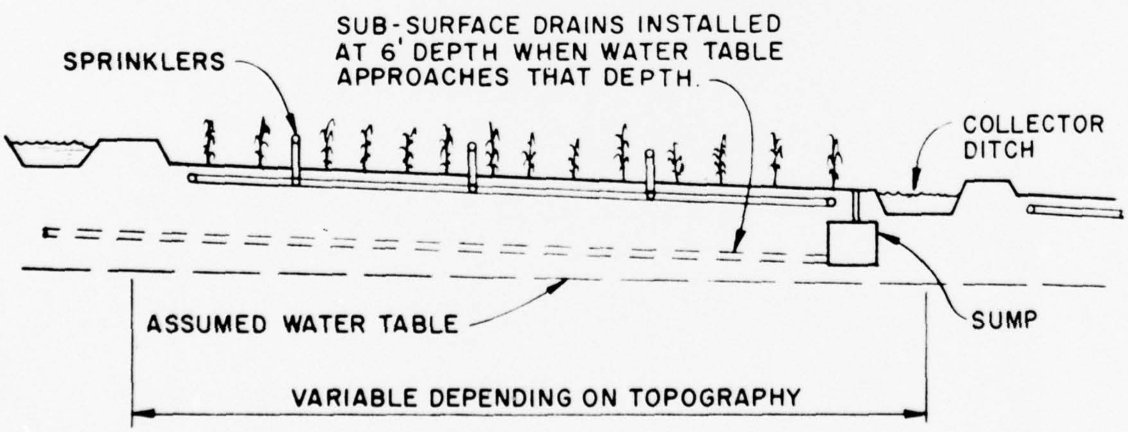
APPLICATION	DRAINAGE
SI = SURFACE IRRIGATION	SD = SURFACE DRAINAGE
SP = SPRINKLERS	G or SSD = GROUNDWATER or SUB-SURFACE DRAINS

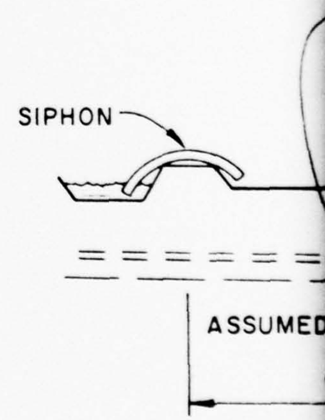



SUB-SURFACE LATERAL LINE
SPRINKLERS
COLLECTOR DITCH
30'-60'
VARIABLE DEPENDING ON TOPOGRAPHY
ASSUMED WATER TABLE


ASSUMED W

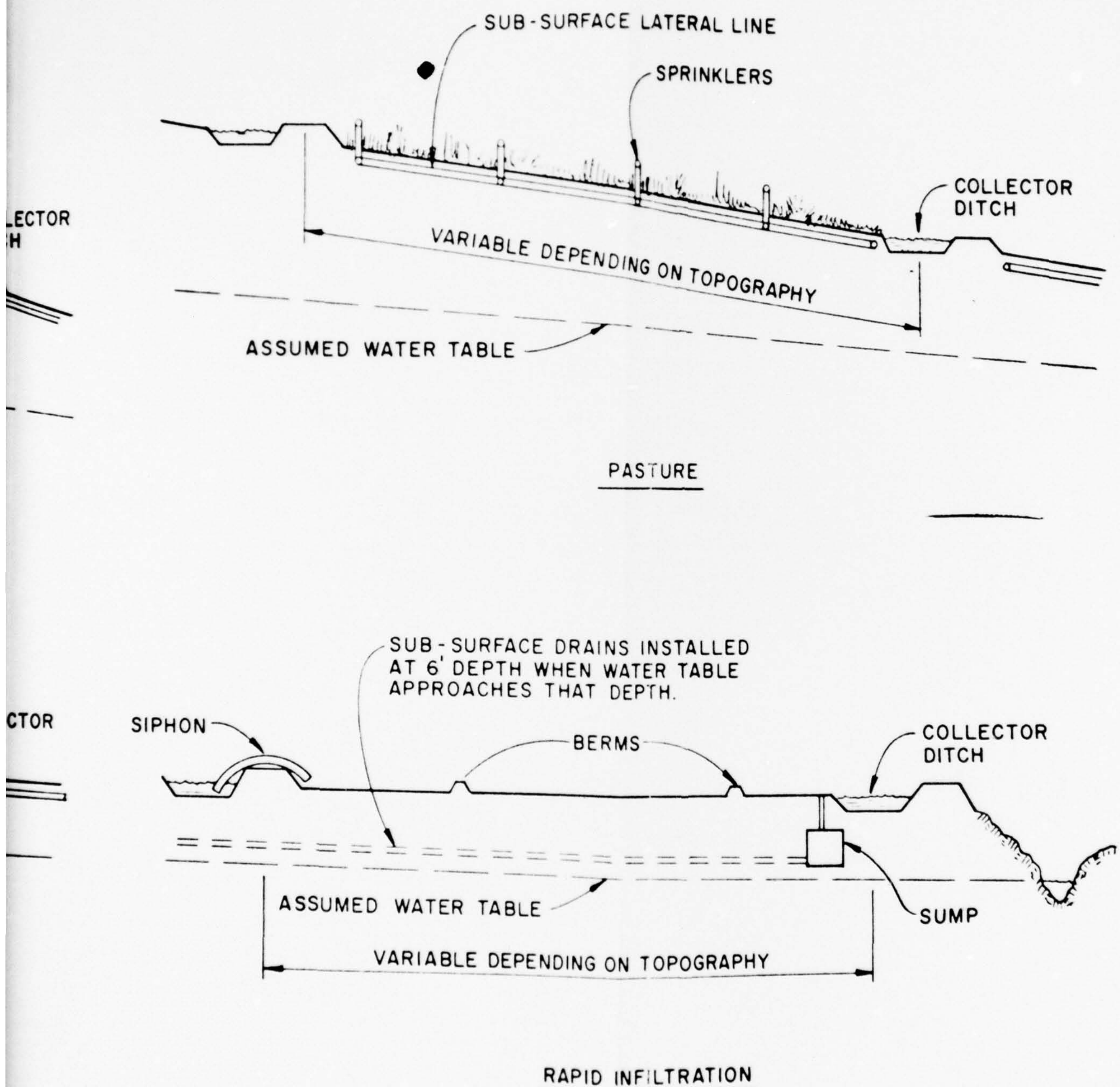
FOREST


SPRINKLERS
SUB-SURFACE DRAINS INSTALLED AT 6' DEPTH WHEN WATER TABLE APPROACHES THAT DEPTH.
COLLECTOR DITCH
SUMP
ASSUMED WATER TABLE
VARIABLE DEPENDING ON TOPOGRAPHY


SIPHON
ASSUMED

CROP

PBQ & D, Inc.



POTENTIAL APPLICATION AND RECOVERY SYSTEM

Figure II-F-8

and may be utilized successfully in a comprehensive drainage and recovery system.

3 - Conveyance and Storage Systems

An investigation of alternative off-site conveyance and storage requirements for the nine selected sites is not included in this report. It is assumed that these facilities will be a combination of open and closed conduits and canals with pumping stations and regulating reservoirs located to take advantage of the natural topography. Storage reservoirs will probably be required at both the effluent source and at the land application site and daily forebay regulation capacity will be required at the pumping plants. Standby pumping capacity and power source will be required for all plants. Right-of-way for all facilities must be carefully considered as well as the solution to the problem of crossing any major waterways.

Figure II-F-9 shows a mass-curve storage capacity analysis for the extreme monthly distributions of annual wastewater applications for Sub-Areas 12.2 and 18.1. From 40 to 55 percent of the total annual application would have to be stored in the sub-area to provide for these variations.

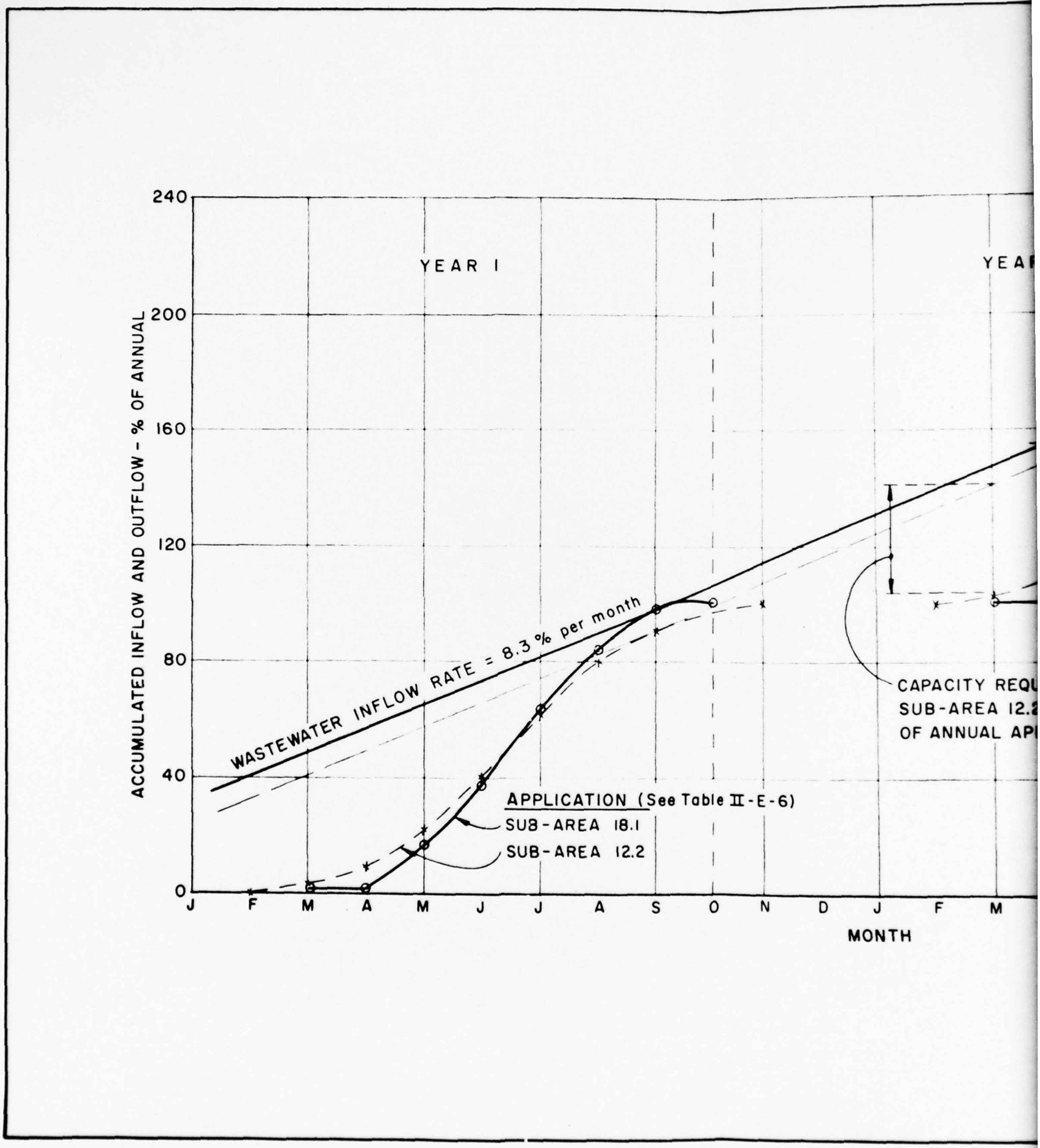
No storage capacity would be required for the rapid infiltration areas under Alternative 3 since the wastewater applications would be uniform throughout the year. However, dead storage requirements, evaporation and seepage losses and provisions for the extreme monthly distributions caused by climatic conditions would have to be considered for each site to determine total storage requirements.

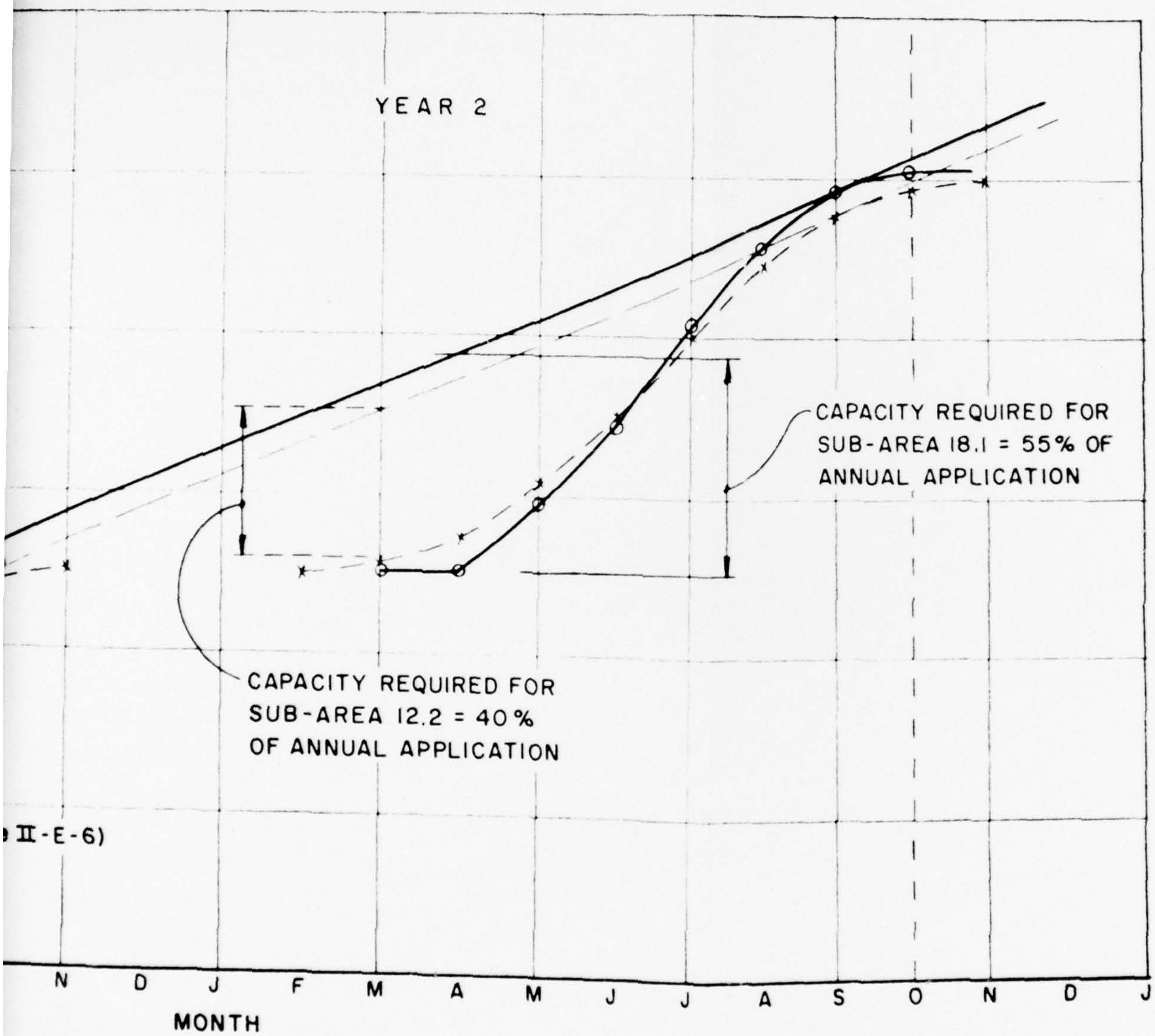
4 - Estimated Development Costs and Crop Values

Tables II-F-1 and II-F-2 give estimated unit development costs and estimated crop and ground cover values for the range of systems, equipment and vegetative covers envisioned for wastewater application sites.

5 - Site Management

An unlimited life has been assumed for wastewater application sites with proper management. As outlined in Section [illegible] of this report, restoration of the soil mantle as a filter medium may be unrestricted if


240
200
160
120
80
40
0
ACCUMULATED INFLOW AND OUTFLOW - % OF ANNUAL
YEAR I
YEA
WASTEWATER INFLOW RATE = 8.3 % per month
APPLICATION (See Table II-E-6)
SUB-AREA 18.1
SUB-AREA 12.2
CAPACITY REQU
SUB-AREA 12.2
OF ANNUAL AP
J F M A M J J A S O N D J F M
MONTH



RESERVOIR STORAGE CAPACITY REQUIRED

Figure II-F-9

Table II-F-1

ESTIMATED UNIT DEVELOPMENT COSTS 1/
(1970 base)

Feature	Capital Expenditure ($ per acre)	Annual Operation & Maintenance 2/ ($ per acre)
Conveyance & Storage	--- 3/	--- 3/
Distribution Systems		
Open Ditch	300 - 350	2 - 5
Buried Pipe	400 - 500	2 - 5
Application Systems		
Open Ditch (furrow, border or basin)	50 - 200 4/	- 0 -
Buried Pipe (furrow, border or basin)	150 - 400 4/	- 0 -
Sprinkler (includes pump)		
Portable	150 - 200	50 - 60
Semi-permanent	500 - 600	50 - 60
Solid Set	600 - 700	50 - 60
Frost Protection (permanent)	800 - 1200	70 - 80
Drainage Systems		
Open Ditch	50 - 100	2 - 5
Closed Subsurface	150 - 200	2 - 5
Wells	50 - 100	5 - 15

1/ Derived from a variety of reports and individuals and intended for use as approximate site development costs.

2/ Does not include labor costs normally associated with farm operations (i.e., land preparation for seeding, irrigation water management, etc.)

3/ Variable depending upon site location and characteristics.

4/ Includes estimated cost of land leveling.

Table II-F-2

ESTIMATED CROP AND GROUND COVER VALUES 1/
(1970 base)

Crop or Cover	Estimated Gross Value ($/acre)
Forests	
Redwood	0 - 150 2/
Monterey pine	0 - 250 2/
Pasture	50 - 150
Forage and Hay	100 - 200
Alfalfa	200
Rice	200 - 250
Grain (cereals)	150
Crops	
Truck	300-600
Field	150-300
Row	150-250
Orchards and Vines	600 - 800
Sugar Beets	250 - 350
Native Vegetation and Marsh Grasses	-0-

1/ From Ref. 28

2/ From Ref. 37

attentive management is exercised. Care in determining suitable cropping patterns, in the design and construction of application and recovery systems, and in determining optimal application and resting cycles and vegetative cover removals and close monitoring of applied and recovered wastewaters should ensure efficient treatment, and optimal vegetative growth while protecting the environment and preventing public health hazards.

G. ENVIRONMENTAL ASSESSMENTS

G. ENVIRONMENTAL ASSESSMENTS

1 - Criteria

The criteria for assessing the potential environmental impacts of applying wastewaters to the selected sites are based on reports prepared by the technical consultants and are summarized in the following paragraphs.

Criteria for Vegetation, Fish, Wildlife and Recreation

1. Wastewater application processes for land units within potential sites which support significant populations of game and non-game species should be designed to maintain the carrying capacity of these areas.

2. Opportunities for the use of wastewater to enhance the productivity of existing wetland areas should be identified.

3. Plant and animal species and unique ecological communities which would be endangered by wastewater application should be identified.

4. Wastewater or reclaimed wastewater which is to be used for recreational purposes in a potential site should be evaluated in relation to the extents of public uses anticipated.

5. Opportunities to use wastewater and reclaimed wastewater for reservoir storage and for augmenting flows in natural stream courses with resulting enhancement of fisheries, wildlife habitats and recreational activities should be identified.

6. Unique historical and archaeological sites which could be endangered by wastewater application should be identified.

7. Transport and distribution facilities and wastewater application methods should be designed for minimum impact on the environment.

8. Anticipated occurrences of ground fog, humidity problems and odor nuisances should be identified.

9. Opportunities for enhancing the overall environmental quality of land units within potential sites should be identified. Such opportunities may include changes in vegetal cover, expansion of the diversity of species and increases in biological productivity.

Criteria for Public Health

1. Percolated wastewater which will be allowed to comingle with water supplies shall exceed the chemical and bacteriological qualities of those supplies. Percolated wastewater which will be used for drinking water shall meet the U. S. Public Health Service Drinking Water Standard.

2. Wastewaters which are planned for use for spray or surface irrigation of produce market crops, processed food crops, dairy pasture and landscaping, and for landscape and recreation impoundments, shall meet the State of California Standards for the Safe Direct Useof Reclaimed Wastewater for Irrigation and Recreational Impoundments.

3. Environmental health factors including communicable diseases and vectors should be assessed in each potential site and control measures outlined.

4. Wastewater application cycles should be designed to avoid over-watering in land units susceptible to the propagation of fungal disease agents.

2 - Vegetation, Fish, Wildlife and Recreation Assessments

This preliminary assessment provides the following information for each of the nine selected sites:

1) Expected plant and animal associations in the site.

2) Populations of selected plants, animals and habitat types.

3) Incidences and potential location of rare or endangered plants and animals.

4) Habitats or ecologies that are valuable, popular or otherwise sensitive to change.

5) Fish, wildlife and recreational use opportunities.

6) Historical and archaeological sites.

7) Recommendations for further site evaluations.

Data gathered for this preliminary assessment includes information from various state and county agencies, from California Department of Fish and Game biologists, and from the California Regional Water Quality Control Board, and is incomplete in many instances. Information for each of the selected sites is summarized in Table II-G-1. A discussion of each selected site is found in Part 4 of this section.

Rare and endangered plants and animals whose distributions fall within the potential wastewater management sites are identified and described as to habitat and locality. Major and/or common fisheries and wildlife are identified for each area, as well as the densities, recreation use and yield of the game species and their distributions relative to habitat types. Public recreational facilities are inventoried as to on-site facilities and uses. The gross recreation reservoir is determined for each area. Unique or critical habitats or ecological situations are identified and discussed.

Vegetation

A list of rare, endangered and possibly extinct plants was compiled for each area from the "Inventory of Rare, Endangered and Possibly Extinct Plants of California" prepared by the California Native Plant Society. Exact locations for each species may be available in the literature or from herbarium specimens, but general distributions are used for each species in this study. As a consequence, some species may be located just outside an area, but may be listed in the area.

The locality and plant community is included for each species named. Plant communities are regional elements of the vegetation which are characterized by the presence of certain dominant plant species. Both climatic and edaphic conditions affect the distribution of plants and thereby regulate plant communities. A complete list of California plant communities with their dominant or indicator species can be found in Munz and Keck's A California Flora. Examples of common communities and some of their indicator species (by common names if available) are summarized below:

Table II-G-1

ENVIRONMENTAL ASSESSMENTS

Site Number	Recreation Facility Name	Recreation Developments: Area (1000 acres)	Picnic Units	Parking Units	Boat Slips	Camping Units	Trails (miles)	Recreation (1000 visitor-days): Recent	Projected Year 2000	Attributes: Scenic Waterway	Recreation Waterway	Waterfowl Flyway	Site Baseline Assessments 1/: Public Health 2/	Fish, Wildlife and Recreation 3/	Site Studies Required 4/
4	Grizzly Island	8.6		300	1			43.9					DV	WFP, WQS, A (1), P (1)	WAS, PEI, WQC, REC
	Suisun Marsh									X	X				
5	Cache Creek	7.7						0.7	1.5	A	II	Site	GW SW, DV	WQS, WSD, FP, GP, P(3)	WAS, WHP, FHD, WEP, DR
	Berryessa Peak	2.3													
	Sacramento River									B	I				
12	Los Banos Creek Reservoir	1.9	20			12		16.1					GW, DV	WSD, WQS, A(3), P(18), FP, GP	DR, WHP
18	Tomales Bay State Park	1.0	35	165			2	129.8	220.2			Site	GW SW	UDV, REC, WQS, WW, WSD, A(2), P(43), GP	LU, WQC, WHP
	Doran Park	0.1		45		200		70.3	119.4						
	Westside Park	0.1			70										
	Monte Rio Parks and Recreation	0.1	6	500	35			175.0	297.1						
	Lawson's Landing	0.3	40	600	35	200									
	Bodega Marine Life Refuge														
	Russian River									C	I				
	Tomales Bay									X	X				
	Bodega Bay										X				
	Lagunitas Creek										I, II				
21	Pine Mountain	7.0											GW, SW	WQS, FP, WW	FAP, WHP, WAS, WQC
	Camp Macama	0.1		15		10	3	5.5	9.3			Site			
	Charles Elsbree	0.5		20		10	3	2.3	3.9						
	Rancho Los Ojitos	1.2					10	4.0	6.8						
	Russian River									C	I				
27	Fremont Peak State Park	0.2	20	50		10	1	26.0	54.0			Site	GW, SW	WSD, SQS, FP, P(27)	WQC, DR, FHP, WHP
	Elkhorn Slough										X				
28	Bean Hollow State Beach	0.1	25										GW	WQS, WSD, FP, A(1), P(6), GP	REC, WQC, WEP, FHP, WHP
	Butano State Beach							50.5	85.7						
	Pescadero State Beach	0.3	25												
	Pomponio State Beach	0.1	10												
	San Gregorio State Beach	0.2	10												
	Portola State Park	1.7	106	104		60	14	147.8	251.0						
	Memorial Park		290	500		144	2	253.5	440.7						
	San Francisco YMCA	0.9						0.5	0.8						
42	Mt. Diablo State Park	7.0	255	350		80	11	281.4	561.5				GW, SW, DV	WQS, UDV, FP, WFP, WSD, A(2), P(15)	AEI, REC, FHP, WHP, PEI
	Royal Oak	0.1	300	500				0.1	0.2						
	Contra Loma Reservoir	0.8													
	Sacramento-San Joaquin Delta and Marsh									X	X				
43	Sacramento Valley, Complex #2	0.1											DV	WQS, WSD, FP, A(1), P(6)	REC, WQC
	Sacramento-San Joaquin Delta and Marsh									X	X				

NOTES:

1/ Assessments listed in order of estimated priority.

2/ GW: Groundwater used for public water supply.

3/ Wildlife:
WFP - Waterfowl protection
GP - Game protection

4/ Required studies listed in order of estimated priority.
Ecology:
AEI - Animal Ecology Inventory

12	Los Banos Creek Reservoir	1.9	20			12		16.1					GW, DV	WSD, WQS, A(3), P(18), FP, GP	DR, WHP
18	Tomales Bay State Park	1.0	35	165			2	129.8	220.2			Site	GW	UDV, REC, WQS, WW, WSD, A(2), P(43), GP	LU, WQC, WHP
	Doran Park	0.1		45		200		70.3	119.4				SW		
	Westside Park	0.1			70										
	Monte Rio Parks and Recreation	0.1	6	500	35			175.0	297.1						
	Lawson's Landing	0.3	40	600	35	200									
	Bodega Marine Life Refuge														
	Russian River									C	I				
	Tomales Bay									X	X				
	Bodega Bay										X				
	Lagunitas Creek										I, II				
21	Pine Mountain	7.0											GW, SW	WQS, FP, WW	FAP, WHP, WAS, WQC
	Camp Macama	0.1		15		10	3	5.5	9.3			Site			
	Charles Elsbree	0.5		20		10	3	2.3	3.9						
	Rancho Los Ojitos	1.2					10	4.0	6.8						
	Russian River									C	I				
27	Fremont Peak State Park	0.2	20	50		10	1	26.0	54.0			Site	GW, SW	WSD, SQS, FP, P(27)	WQC, DR, FHP, WHP
	Elkhorn Slough										X				
28	Bean Hollow State Beach	0.1	25										GW	WQS, WSD, FP, A(1), P(6), GP	REC, WQC, WEP, FHP, WHP
	Butano State Beach							50.5	85.7						
	Pescadero State Beach	0.3	25												
	Pomponio State Beach	0.1	10												
	San Gregario State Beach	0.2	10												
	Portola State Park	1.7	106	104		60	14	147.8	251.0						
	Memorial Park		290	500		144	2	253.5	440.7						
	San Francisco YMCA	0.9						0.5	0.8						
42	Mt. Diablo State Park	7.0	255	350		80	11	281.4	561.5				GW, SW, DV	WQS, UDV, FP, WFP, WSD, A(2), P(15)	AEI, REC, FHP, WHP, PEI
	Royal Oak	0.1	300	500				0.1	0.2						
	Contra Loma Reservoir	0.8													
	Sacramento-San Joaquin Delta and Marsh									X	X				
43	Sacramento Valley, Complex #2	0.1											DV	WQS, WSD, FP, A(1), P(6)	REC, WQC
	Sacramento-San Joaquin Delta and Marsh									X	X				

NOTES:

1/ Assessments listed in order of estimated priority.

2/ GW: Groundwater used for public water supply.
SW: Public exposure of surface water.
DV: Presence of disease vectors (leptospirosis, schistomiosis, mosquito, Valley Fever).

3/ Wildlife:
- WFP - Waterfowl protection
- GP - Game protection
- FP - Fish and fishery protection

Waterways:
- WW - Waterway (recreational fishing)

Water Resources:
- WSD - Water Supply Deficiency
- WQD - Water Quality Deficiency
- WQS - Water Quality Sensitivity

Rare and Endangered Species:
- P( ) - Plants (#)
- A( ) - Animals (#)

Urban Development:
- UDV - Urban Development

4/ Required studies listed in order of estimated priority.
Ecology:
- AEI - Animal Ecology Inventory
- PEI - Plant Ecology Inventory

Potential Habitat Development:
- FHP - Fish Habitat Potential
- WHP - Wildlife Habitat Potential

Water Resources:
- WQC - Water Quality Changes
- WAS - Water Application Schedules (Detailed)
- WEP - Waterway Enhancement Potential
- DR - Drainage

Recreation and Land Use:
- REC - Recreational Facilities and Uses
- LU - Land Uses

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Plant Community	Some Indicator Species
Valley grassland	Annual grass species of (Bromus, Festuca, Avena, Stipa)
Chaparral	Chamise, toyon, coffee-berry, California lilac, manzanita
Foothill woodland	Digger pine, black oak, valley oak, interior live oak, coast live oak, California bay, California buckeye
Redwood forest	Coast redwood, Douglas fir, tanbark oak, Rhododendron, wax myrtle
Closed-cone pine forest	Monterey pine, Bishop pine, beach pine, Monterey cypress

Comparisons of vegetative cover types, habitat types and plant communities are given in Table II-C-2. Only those cover types, plant communities or habitat types which are in the wastewater management areas are included. Corresponding vegetative designations are shown on the same horizontal line, and overlapping designations are indicated by a line between the two different designations.

Fish and Wildlife

The wildlife within each wastewater management area is reported by habitat types. Habitat types are based on recurrent assemblages of certain key plant species or types. California habitat types are listed in the California Fish and Wildlife Plan (Vol. III, Part A). Examples of habitat types and their indicator plant species are shown below:

Habitat Type	Indicator Species
Redwood forest	Coast redwood, Douglas fir, California laurel (bay), tan-bark oak, Rhododendron, madrone
Coastal forest	Douglas fir, redwood, California laurel, tan-bark oak, madrone
Hardwood	Live oak, black oak

Table II-G-2

COMPARISONS OF COVER TYPES,
CALIFORNIA HABITAT TYPES
AND PLANT COMMUNITIES

Cover Types	California Habitat Types	Plant Communities
Coniferous forest	Redwood forest	Redwood forest
	Coastal forest	Douglas fir forest
	Pine-fir-chaparral	Yellow pine forest
	Minor conifers	Closed-cone pine forest
Hardwoods	Hardwood	Mixed evergreen forest
	Woodland-chaparral	
	Woodland-sagebrush	Foothill woodland
	Woodland-grasses	Northern oak woodland
Grass-Forbs	Grasslands	Valley grassland
		Coastal prairie
Chaparral-Mt. Brush	Chaparral	Chaparral
		Northern coastal scrub
		Coastal strand
	Coast sagebrush	Coastal sage scrub
Southern Desert Shrub	Saltbrush-buckwheat	
Pinyon-Juniper	Juniper-Pinyon pine	Pinyon juniper woodland
Marsh	Marsh	Coastal salt marsh
	Seasonal marsh	Freshwater marsh
Water	Lakes, bays, reservoirs	
Agriculture	Agriculture	
Urban	Urban industrial	
Barren	Barren	

Chaparral	Chamise, manzanita, Ceanothus
Woodland grass	Oaks, broadleaf trees, grasses
Grassland	Filaree, fescue, cheat grass, brome, soft chess

Plant communities and habitat types are not synonymous, although they generally have the same plant indicator species. Comparisons among cover types, habitat types, and plant communities are given in Table II-G-2. However, this listing represents only a cursory comparison of these different vegetative designations.

Fish and wildlife data, species identifications and densities, hunting and fishing uses, and rare or endangered status designations are derived from California Department of Fish and Game publications and other sources including the California Fish and Wildlife Plan. Table II-G-3 contains a list of the principal game and non-game fish, birds and mammals found in the study areas. The number of species of mammals in California is considerably smaller than the number of species of birds, and their distribution lends itself to cursory survey much more readily than does the distribution of birds. Consequently, the mammal list given for the wastewater management areas contains most of the mammals, while the bird list is restricted to the game birds and raptors of importance.

Waterways

The California Protected Waterways Plan (Initial Elements, 1971) is the first report to the California Legislature of the investigations carried out under the California Protected Waterways Program as required by the Protected Waterways Act (1968). Part of the study required "the identification of those waterways of the state possessed of extraordinary scenic, fishery, wildlife or outdoor recreation resources." The term "waterways" was defined by the California Protected Waterways Act to include, "the waters and adjacent lands of streams, channels, lakes, reservoirs, bays, estuaries, marshes, wetlands and lagoons." This study identified and classified the extraordinary waterways for each of the major categories: scenic, fishery, wildlife and recreation. A master list of extraordinary waterways was compiled from these individual evaluations.

The California Protected Waterways Plan was used in this study to identify the extraordinary waterways in each area and to rate them as to relative importance for each of the major categories (scenic, fisheries,

Table II-G-3

PARTIAL LIST OF FISHES, BIRDS AND MAMMALS
FOUND IN STUDY AREAS

Anadromous Fish

Common Name		Scientific Name
White sturgeon	-	Acipenser transmontanus
Green sturgeon	-	Acipenser medirostris
American shad	-	Alosa sapidissima
King salmon	-	Oncorhynchus tshawytscha
Silver salmon	-	Oncorphynchus kisutch
Brown trout	-	Salmo trutta
Coast cutthroat trout	-	Salmo clarkii clarkii
Rainbow trout (inland) (ocean-steelhead)	-	Salmo gairdnerii
Sucker	-	Catostomus spp.
Carp	-	Cyprinus carpio
Sacramento blackfish	-	Orthodon microlepidotus
Hardhead	-	Mylopharodon conocephalus
Sacramento squawfish	-	Ptychocheilus grandis
Splittail	-	Pogonichyhys macrolepidotus
Channel catfish	-	Ictalurus punctatus
White catfish	-	Ictalurus catus
Brown bullhead	-	Ictalurus nebulosus
Black bullhead	-	Ictalurus melas
Yellow bullhead	-	Ictalurus natalis
Striped bass	-	Roccus saxatilis
Yellow perch	-	Perca flavescens
Smallmouth bass	-	Micropterus dolomieui
Largemouth bass	-	Micropterus salmoides
Green sunfish	-	Lepomis cyanellus
Redear sunfish	-	Lepomis microlophus
Bluegill	-	Lepomis macrochirus
Sacramento perch	-	Archoplites interruptus
White crappie	-	Pomoxis annularis
Black crappie	-	Pomoxis nigromaculatus
Tule perch	-	Hysterocarpus traski

Mammals

Common Name		Scientific Name
Black-tailed deer	-	Odocoileus hemionus columbianus
Tule elk	-	Cervus nannodes
Feral pig	-	Sus sp.
Black bear	-	Ursus americanus
Kit fox	-	Vulpes macrotis
Grey fox	-	Urocyon cinereoargenteus
Coyote	-	Canis latrans
Mountain lion	-	Felis concolor
House cat	-	F. domesticus
Bobcat	-	Lynx rufus
Beaver	-	Castor canadensis
Muskrat	-	Ondatra zibethica
Porcupine	-	Erethizon eqixanthum
Opossum	-	Didelphis virginiana
Raccoon	-	Procyon lotor
Ring-tailed cat	-	Bassariscus astutus
Pine marten	-	Martes caurina
Long-tailed weasel	-	M. frenata
Mink	-	M. vison
River otter	-	Lutra canadensis
Spotted skunk	-	Spilogale gracilis
Striped skunk	-	Mephitis mephitis
Badger	-	Taxidea taxus
Black-tailed jackrabbit	-	Lepus californicus
Audubon cottontail	-	Sylvilagus audubonii
Brush rabbit	-	S. bachmani
Chickaree	-	Tamiasciurus douglasii
Grey squirrel	-	Sciurus griseus
Eastern fox squirrel	-	S. niger
Eastern grey squirrel	-	S. carolinensis
Moles	-	Scapanus latimanus
Shrews	-	Sorex spp.
Bats	-	Numerous species of order Chiroptera
California ground squirrel	-	Citellus beecheyi
San Joaquin antelope squirrel	-	Ammospermophilus nelsoni
Townsend chipmunk	-	Eutamias townsendi
Sonoma chipmunk	-	E. sonomae
Merriam chipmunk	-	E. merriami
Valley pocket gopher	-	Thomomys bottae
Little pocket mouse	-	Perognathus longimembris
San Joaquin pocket mouse	-	P. inornatus

Common Name		Scientific Name
California pocket mouse	-	P. californicus
Heermann kangaroo rat	-	Dipodomys heermanni
Giant kangaroo rat	-	D. ingens
Santa Cruz kangaroo rat	-	D. venustus
Fresno kangaroo rat	-	D. nitratoides
Western harvest mouse	-	Reithrodontomys megalotis
Salt marsh harvest mouse	-	R. raviventris
California mouse	-	Peromyscus californicus
Deer mouse	-	P. manicalatus
Brush mouse	-	P. boylei
Pinon mouse	-	P. truei
Southern grasshopper mouse	-	Onychomys torridus
Desert woodrat	-	Neotoma lepida
Dusky-footed woodrat	-	N. fuscipes
California vole	-	Microtus californicus
Pacific jumping mouse	-	Zapus trinotatus
Red-backed mouse	-	Clethrionomys occidentalis
Old world rats	-	Rattus spp.
Old world mouse	-	Mus musculus
Mountain beaver	-	Aplodontia rufa

Birds (Game, Waterfowl, Raptors)

Blue grouse	-	Dendragapus fuliginosus
Chukar partridge	-	Alectoris graeca
California quail	-	Lophortyx californica
Mountain quail	-	Oreortyx picta
Ring-necked pheasant	-	Phasianus colchicus
Wild turkey	-	Meleagris gallopavo
Band-tailed pigeon	-	Columba fasciata
Domestic pigeon	-	Columba livia
Mourning dove	-	Zenaidura macroura
Trumpeter swan	-	Olor buccinator
Western Canada goose	-	Branta canadensis occidentalis
Great Basin Canada goose	-	B. c. moffitti
Lesser Canada goose	-	B. c. leucopareia
Cackling goose	-	B. c. minima
Black brant	-	B. nigricans
White-fronted goose	-	Anser albifrons
Snow goose	-	Chen hyperborea
Ross goose	-	C. rossii
Mallard	-	Anas platyrhynchos
Gadwall	-	A. strepera

Common Name		Scientific Name
Pintail	-	A. acuta
Green-winged teal	-	A. carolinensis
Cinnamon teal	-	A. cyanoptera
American widgeon	-	Mareca americana
Shoveler	-	Spatula clypeata
Wood duck	-	Aix sponsa
Canvasback	-	A. valisineria
Greater scaup	-	A. marila
Lesser scaup	-	A. affinis
Common goldeneye	-	Bucephala clangula
Barrow's goldeneye	-	B. islandica
Bufflehead	-	B. albeola
White-winged scoter	-	Melanitta deglandi
Surf scoter	-	M. perspicullata
Common scoter	-	Oidemia nigra
Ruddy duck	-	Oxyura jamaicensis
Hooded merganser	-	Lophodytes cucullatus
Common merganser	-	Mergus merganser
Red-breasted merganser	-	M. serrator
Blue heron	-	Areda herodias
Common egret	-	Casmerodius albus
Snowy egret	-	Leucophoyx thula
Black-crowned night heron	-	Nycticorax nycticorax
Sandhill crane	-	Grus canadensis
California clapper rail	-	Rallus longirostris obsoletus
Gallinule	-	Gallinula chloropus
Coot	-	Fulica americana
Common snipe	-	Capella gallinago
Glossy ibis	-	Plegadis guarauna
Condor	-	Gymnogyps californianus
White-tailed kite	-	Elanus leucurus
Golden eagle	-	Aquila chrysaetos
Bald eagle	-	Haliaeetus leucocephalus
Prarie falcon	-	Falco mexicanus
Peregrine falcon	-	Falco peregrinus
Marsh hawk	-	Cirus cyaneus
Red-tailed hawk	-	Buteo jamaicensis
Sparrow hawk	-	Falco sparverius

wildlife and recreation).

The classification system used in the California Protected Waterways Plan to evaluate the waterways is as follows:

"Class I - Premium waterways. Statewide interest and importance usually involved; attract visitors from throughout the State.

"Class II - Very good waterways. Regional interest and importance usually involved; attract visitors from a less than statewide area, normally within about a 200-mile radius. These waterways have high values . . . but they rank just below those in Class I.

"Class III - Important waterways. County-wide interest and importance usually involved; used primarily by residents of the county. Criteria evaluation ranks these just below those in Class II."

The criteria used for evaluating and rating each waterway are as follows:

1) The size, present and potential ability to produce and support fish and wildlife populations;

2) The quality and quantity of the fishery and wildlife resources produced;

3) The presence of rare or endangered species;

4) Present and future potential human use (quality and quantity) including scientific and education pursuits;

5) Present and future availability of the waterway for public use;

6) Presence of critical environmental requirements;

7) Geographical location related to scarcity;

8) Aesthetic condition; and

9) Access, condition and facilities.

The four major categories (scenic, fishery, wildlife and recreation) are sub-divided based on type of waterway, type of resources, scenic quality or recreation usage. Farm ponds throughout the state are classified as Class I lakes and reservoirs in the wildlife waterway evaluations. Waterways within each potential wastewater management area are recorded as to their classification in the California Protected Waterways Plan.

Recreation

The majority of the inventory of existing recreation supplies was determined by an analysis of existing state, county and local listings of recreation facilities in their respective jurisdictions.

Natural features such as waterfowl flyway routes and water bodies capable of supporting recreation are identified since these features significantly affect the recreation potential for the study areas.

The participation day estimates given in Table II-G-4 represent the potential of recreation demand which might be available to a site, that is, the total demand from which a prospective facility might draw users. The portion of potential demand which can be attracted to any given site depends upon the natural and/or man-made site amenities and upon the public tastes at the time a proposed site is available for public use.

All estimates of recreational demand are for the year 1970 and are based on the variables identified in the demand subsystem of the Park and Recreation Information System. These include population forecasts, socio-economic characteristics of the population, per capita demand for recreation activity by socio-economic characteristics, and distribution of demand for recreation activity by travel zone.

The methodology used was as follows. Major population centers were identified which were within 0 to 4+ hours travel distance to a specific wastewater management area. It was then determined which specific travel zone from each relevant city coincided with the area in question. The number of recreation days attributable to each travel zone was calculated for each city and then the figures for the zones coinciding with the wastewater management area were summed to achieve a total representing a reservoir of generalized (i.e., non-specific) recreationists from which a recreation facility might draw users (see Figure II-G-1).

Table II-G-4

ESTIMATED RECREATION POTENTIAL 1/

Selected Site No.	Estimated Annual Recreation Potential (million visitor-days)
4	281
5	109
12	112
18	254
21	105
27	121
28	109
42	266
43	26[illegible]

NOTES:

1/ Represents the total available reservoir of recreation from which a site may draw its recreation use.

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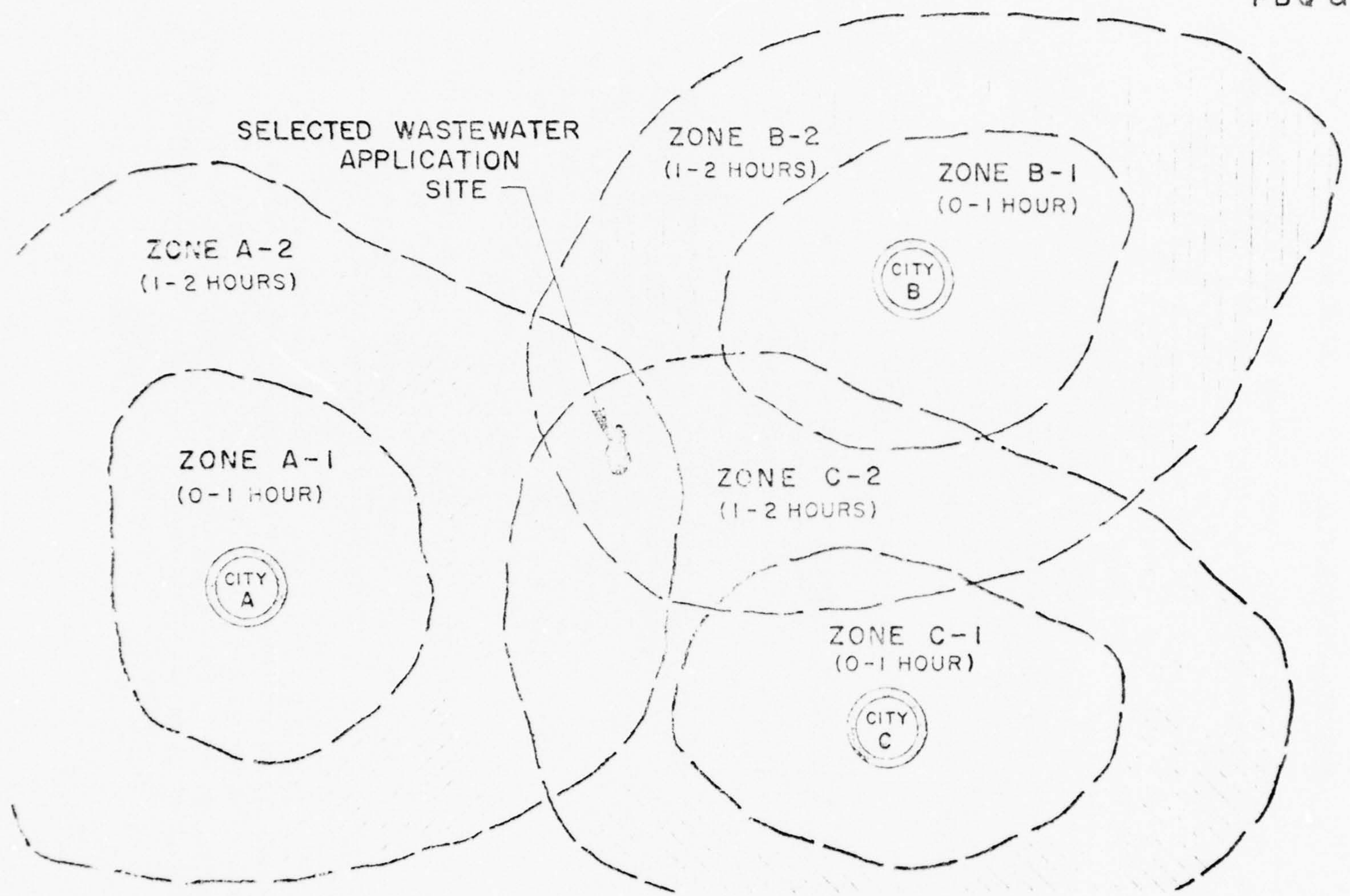

METHODOLOGY FOR ESTIMATING POTENTIAL RECREATION DEMANDS

Figure II-G-1

Historical and Potential Archaeological Sites

Table II-G-5 shows a tabulation of historical landmarks identified in the selected sites and indicates the archaeological potential of each site.

3 - Public Health

Table II-G-1 indicates potential public health hazards anticipated for each of the nine selected sites. The following paragraphs outline currently permissible and desirable water quality standards and general environmental controls and identify some specific public health hazards and suitable control measures.

Water Quality Standards

Minimum Requirements. Minimum requirements for wastewater quality prior to application where public contact is possible but ingestion is unlikely and where open channels and storage reservoirs are used are as follows:

1) Bacteriological. For secondary effluent, the Median MPN should not exceed 23/100 ml (Ref. 71). The possibility of contamination of wastewater with disease organisms should be recognized. The presence of pathogenic bacteria and viruses must be suspected and appropriate processes utilized to maintain the above criterion.

2) Physical. Aerobic conditions should be maintained for odor control and waters should be substantially free from floatable materials that can be recognized as being of sewage origin.

Infiltration Requirements. Direct injection of reclaimed wastewater to replenish aquifers or to create barriers against saltwater intrusion can be practiced only with high quality water. Reclaimed wastewater intended for aquifer replenishment must meet the following listed levels in addition to meeting the minimum requirements:

1) Nitrates - not over 10.0 mg/1

2) Phosphates - not over 1.0 mg/1

Table II-G-5

HISTORICAL AND POTENTIAL ARCHAEOL

SITE	HISTORICAL LANDMARKS	
4	None	Li un
5	Stephens adobe - Rancho Canada de Capay - only adobe structure standing in Yolo County	Ei ex ex
12	Remains of Indian villages have been uncovered at various water holes and Indian trails can still be traced	Sl
18	Church of Our Lady of Loretto (at Nicasio)	Es he
21	Church of Our Lady of Mount Carmel (at Asti) Part of the adobe house of Cyrus Alexander (built 1845-46) still stands Rancho San Miguel - burial grounds in rolling hills near Mark West Creek	Es he
27	None	Fo no
28	None	Es sy
42	Stone house of Dr. John Marsh, located near Brentwood - owned by Contra Costa County	Es sy
43	None	Es fi me gr

SOURCE:

Corps of Engineers letter dated June 5, 1972.

Table II-G-5

AND POTENTIAL ARCHAEOLOGICAL SITES

	ARCHAEOLOGICAL POTENTIAL
	Limited to low foothills on site periphery - no site survey has been undertaken and no future plans exist
adobe structure	Eight feasible archaeological sites have been identified but not excavated - excellent potential in valleys where a drainage system exists or existed
various	Slight - lack of surface waters indicates that finds would be scattered
	Estimated that a site exists every 1/2 mile along any drainage system - heavily populated by Pomo Indians
845-46) near	Estimated that a site exists every 1/2 mile along any drainage system - heavily populated by Pomo Indians
	Foothills along Monterey Bay and Salinas River Valley may contain sites - no surveys have been conducted
	Estimated that sites would be few, scattered and located near drainage systems - no surveys have been conducted
wood -	Estimated that sites would be few, scattered and located near drainage systems - no surveys have been conducted
	Estimated to be probably the most important area with respect to archaeological finds - sites dating to 3,000 years old have been excavated between Sacramento and Stockton: the proximity of site 43 and its drainage systems indicates great potential - scattered site surveys have been productive

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3) Sodium Ratio (Na/K + Na + Mg) not over 50%

4) Heavy Metals - not over 0.1 mg/l

5) Boron - not over 0.4 to 2.0 mg/l, depending on tolerance of site plant life.

6) Pathogens and Viruses - Median Coliform MPN of 2/100 ml

7) Floatables, dissolved organics and grease should be removed to prevent plugging of aquifers and subsequent decomposition.

8) Other constituents - should meet U.S. Public Health Service Drinking Water Standards, the American Water Works Association Potable Water Quality Goals and/or the Environmental Protection Agency Recommended Desirable Criteria (see Table II-G-6).

The California Health and Safety Code (Ref. 71) establishes additional standards and regulations for groundwater replenishment using reclaimed wastewater.

<u>Vegetative Use Requirements</u>. The California Administrative Code (Refs. 72, 73) indicates detailed control standards for the use of reclaimed wastewater for irrigation purposes. General guidelines are outlined below in addition to dechlorination, which may be required prior to applications.

1) Reclaimed wastewater applied by spray irrigation will generally need to conform only to the minimum standards when used on fodder, fiber, seed crops and processed food crops such as the following:

Alfalfa,
Pasture used only by beef cattle,
Rice,
Other grains and cereals,
Deciduous orchards only if nuts or olives,
Sugarbeets,
Row crops only if subsequently processed,

Table II-G-6

WATER QUALITY OBJECTIVES FOR PUBLIC WATER SUPPLIES

Characteristic	Units	U. S. Public Health Service Water Standards 1/ Desirable/Permissible	American Water Works Association Potable Water Quality Goals 2/	EPA/FWPCA Recommended Surface Water Quality Criteria 3/ Desirable/Permissible
Physical				
Color	Color Units	15	3	under 10/75
Turbidity	Turb. Units	5	0.1	VA/*
Odor	Threshold Units	3	A	VA/*
Taste	Taste Units	NO	NO	*
Chemical				
Alkalinity (as $CaCO_3$)	mg/l	30-500 (min-max)	variable	30-500 (min-max)
Aluminum	mg/l	*	0.05	*
Ammonia (as N)	mg/l	*	*	under 0.01/0.5
Arsenic	mg/l	0.01/0.05	*	A/0.05
Barium	mg/l	1.0	*	A/1.0
Cadmium	mg/l	0.01	*	A/0.01
Carbon Alcohol Extract Organics 4/	mg/l	*	0.1	*
Carbon Chloroform Extract Organics 5/	mg/l	0.2/*	0.04	0.04/0.15
Chloride	mg/l	250/*	*	under 25/250
Chromium (hexavalent)	mg/l	0.05	*	A/0.05
Copper	mg/l	1.0/*	0.5	VA/1.0
Cyanide	mg/l	0.01/0.2	*	A/0.2
Detergents	mg/l	0.5/*	0.2	VA/0.5
Fluoride	mg/l	1.2/1.7	*	*
Iron	mg/l	0.3/*	0.05	VA/0.3
Lead	mg/l	*/0.05	0.05	A/0.05
Manganese	mg/l	0.05/*	0.01	A/0.05
Mercury	mg/l	0.0005	*	*
Nitrate	mg/l	45/*	*	VA/10
Phenols	mg/l	0.001	*	A/0.001
Selenium	mg/l	*/0.01	*	A/0.01
Silver	mg/l	*/0.05	*	A/0.05
Sulfate	mg/l	250/*	*	under 50/250
TDS	mg/l	500/*	200	under 200/500
TSS	mg/l	*	VA	*

Extract Organics 4/				
Carbon Chloroform	mg/l	0.2/*	0.04	0.04/0.15
Extract Organics 5/				
Chloride	mg/l	250/*	*	under 25/250
Chromium (hexavalent)	mg/l	0.05	*	A/0.05
Copper	mg/l	1.0/*	0.5	VA/1.0
Cyanide	mg/l	0.01/0.2	*	A/0.2
Detergents	mg/l	0.5/*	0.2	VA/0.5
Fluoride	mg/l	1.2/1.7	*	*
Iron	mg/l	0.3/*	0.05	VA/0.3
Lead	mg/l	*/0.05	0.05	A/0.05
Manganese	mg/l	0.05/*	0.01	A/0.05
Mercury	mg/l	0.0005	*	*
Nitrate	mg/l	45/*	*	VA/10
Phenols	mg/l	0.001	*	A/0.001
Selenium	mg/l	*/0.01	*	A/0.01
Silver	mg/l	*/0.05	*	A/0.05
Sulfate	mg/l	250/*	*	under 50/250
TDS	mg/l	500/*	200	under 200/500
TSS	mg/l	*	VA	*
Zinc	mg/l	5/*	1	VA
Bacteriological				
Coliform organisms	#/100ml.	*	*	under 100/10,000
-multiple-tube technique	MPN 6/	2	A	*
-membrane-filter technique				
mean monthly	#/100ml	1	A	*
per sample	#/100ml	4	*	*
Fecal Coliforms	#/100ml	*	*	under 2 /20,000
Radiological				
Gross Beta Activity	pc/l 7/	1000	100	under 100/1000

NOTES:

1/ From Ref. 87
2/ From Ref. 88
3/ Criteria developed by the former Federal Water Pollution Control Administration and the Environmental Protection Agency.
4/ Potentially toxic organic contaminants including insecticides, herbicides, other agricultural chemicals, nitriles, orthonitrobenzenes, aromatic ethers, waste hydrocarbons, synthetic detergents and other synthetic organic chemicals.
5/ Potentially toxic organic contaminants including chlorinated insecticides, nitrobenzene and aromatic ethers.
6/ Most Probable Number (a standard index for coliform organisms).
7/ Pico-curies/liter (the rate of disintegration for one gram of radium).
* No standard given.
NO Not objectionable
A Absent
VA Virtually absent

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Safflower,
Vines only if raisin or wine grapes, and
Beans only if dried.

2) Reclaimed wastewater applied by spray irrigation will require secondary filtration and must be disinfected to a Median MPN of 2.2/100 ml when used on the following crops:

Pasture used by dairy cows or goats,
Fruit tree orchards,
Truck gardens,
Field crops,
Table grape vines, and
Green beans.

3) Reclaimed wastewater applied to Redwood or Monterey pine forests by spray application must conform only to the minimum standards.

Environmental Controls

The following procedures should be followed in the management of any potential wastewater site:

1) Abandoned wells should be sealed and capped to prevent uncontrolled introduction of wastewater into aquifers.

2) Corridors should be provided to isolate wastewater application areas from communities, highways, railroads, natural watercourses and recreation areas. Corridors should be at least 300 feet in width and no more than 600 feet when prevailing winds may carry mists, dust or odors.

3) Reclaimed wastewater should be sampled and analyzed daily for:

a) settleable solids,
b) coliform bacteria (MPN),
c) chlorine residual,
d) gross heavy metals,
e) organic contaminants,

f) turbidity (where spray irrigation of non-processed food crops and dairy animal use of pastures occur), and
g) nitrates (where rapid infiltration is used).

4) Groundwater and adjacent water courses should be monitored to detect quality level changes.

5) Insects and animal pests should be monitored to minimize exposure to disease vectors.

6) Vegetative covers should be sampled and analyzed to determine toxic substance uptakes.

7) General surface and atmospheric conditions should be monitored for odor and nuisance control.

8) Land application sites should be clearly marked to notify the public that reclaimed wastewater is being used. Signing should be graphic and conspicuously placed, and

9) Infiltration fields, reservoirs and both sides of open canals should be fenced. Safety ropes and life rings should be provided at road crossings of open conveyance canals.

Health Hazards and Controls

Pathogens. The most serious potential public health hazard resulting from wastewater application is the presence of pathogenic micro-organisms. Potential contamination is related to the following conditions:

1) Leaching and percolation of untreated wastewaters into groundwater and surface waters,

2) Air-borne transport by winds,

3) Direct human contact, and

4) Contact through harvested crops.

Potential contamination can be controlled by:

1) Proper management of secondary treatment processes to maximize disinfection,

2) Additional disinfection of secondary treatment plant effluents,

3) The selective utilization of soils and subsoils with fine filtering (and pathogen removal) capabilities,

4) The isolation of wastewater application areas from public accessibility,

5) The carefully managed use of hedgerows and densely covered buffer zones to provide filtering root systems and habitats for vector-preying animals, and

6) Carefully managed application systems to include the timing of applications to minimize contact opportunities and the control of loading and resting cycles to provide maximum soil treatment efficiencies.

Toxic Substances. The uptake of heavy metals and other potentially toxic substances by harvested and consumed crops and the concentration of these substances in the leachate constitute a possible public health hazard. Occurrences of nearly toxic concentrations of heavy metals in edible crops have been reported but are few. Monitoring of potentially dangerous substances in crops and recovered waters is, however, recommended. Efforts to prevent this potential hazard should include:

1) Stringent control of industrial discharges,

2) Proper management of secondary treatment processes to maximize TDS and nitrogen removals,

3) Incorporation of varied selective processes such as multi-cell aeration, high-lime treatment, ammonia stripping, selective ion exchange,

aerobic-anaerobic lagooning, algae lagooning and reverse osmosis for the removal of specific potentially toxic substances,

4) Utilization of soils and subsoils with fine filtering capabilities, and

5) Careful wastewater management to provide harvesting of vegetation at appropriate times and to maximize soil-treatment removals while minimizing uptake of toxic substances.

<u>Vectors.</u> Disease-carrying animals and insects (vectors) may be encouraged by ponding of wastewater and certain application methods and represent a potential public health hazard. The primary vector is the mosquito and the most dangerous associated disease is valley fever, a form of encephalitis or sleeping sickness. A second important vector-borne disease is leptospirosis, a bacterial infection which is transmitted to waters by vectors attracted to grasses and other low vegetation. A more remote vector-borne disease is virulent schistosomiasis, carried by particular species of water snails occurring in ponds and associated with improperly sloping or uncleaned ditches.

These potential health hazards can be prevented by:

1) Attaining adequate pathogen removal as previously outlined,

2) Minimizing long-term ponding,

3) Cleaning and good management of open waterways,

4) Cautious introduction of vector-preying animal life such as mosquito-eating fish (Gambusia affinis), and

5) Careful use of selected insecticides and pesticides.

<u>4 - Site Discussions</u>

The completed site surveys present overviews of the ecological systems in the selected sites. Sufficient data are available to describe the general environmental effects of wastewater application and to determine the relative scopes of potential environmental problems created for the sites.

An environmental assessment of the selected sites is given in Volume V.

In most cases detailed information on the life cycle and species-habitat interrelationships of dominant species in an area is necessary to define environmental systems, the socio-economic structures of private and public facilities (particularly in the Russian River and coastal areas) may require definition for a complete evaluation of recreational resources.

Based on the information gathered, the nine selected wastewater application sites have been rated in terms of desirability for proposed use and in regard to the amount of work required to perform an environmental assessment according to current federal guidelines.

The rating is solely for fish, wildlife and their use and does not include judgemental values related to other potential beneficial uses. Judgement was influenced by the amount of technical information available, the present quality of the wildland resource, what could be achieved with management of the proposed project to enhance wildland benefits, and the sensitivity of an area in relation to public reaction to implementation of a wastewater reuse project. The latter evaluation is for fish and wildlife and recreational uses only.

Table II-G-7 lists the sites in estimated order of priority for the proposed use and identifies concerns and subject areas that need concentrated study in estimated order of priority for receiving attention. None of the sites was rated as undesirable at this time; however, further study may show that at least some sub-areas are altogether undesirable for use. Initially all wastewater application sites must be researched in order to give assurance that endangered and rare species are being protected in accordance with federal and state policies.

Estimates of the work required to truly ascertain the acceptability of sites for proposed uses can be based on evaluations of existing data in relation to the concerns identified in Table II-G-7. For example, Sites 4 and 43 have been intensively studied by the Department of Fish and Game while Site 42 has received little attention. Generally, this difference reflects their importance for fish and wildlife uses. Site 42 has minor use for fish and wildlife at present, but may potentially be very useful if water is brought into the area. Sites 4 and 43 need in-depth study in special situations as noted in Table II-G-7, while Site

42 may need a more general study, overall. Based on our judgement, the proposed sites would require environmental assessment studies of magnitudes corresponding to low, moderate and intensive levels of effort as follows:

Low	Moderate	Intensive
12	4	18
27	5	21
42	43	28

The California Department of Fish and Game and other state agencies are now compiling data, describing environmental relationships and drawing conclusions relative to water quality management as part of the state-wide basin planning effort. It is assumed that a considerable amount of useful information will be forthcoming from the state's study. Their reports are due for distribution in July 1972. Reassessments of the need for extensive data collection and interpretation programs for each of the proposed wastewater application sites may be made after these reports become available.

Table II-G-7

ADDITIONAL ENVIRONMENTAL STUDIES

Sites		Topics for Investigation
5, 12, 27, 42	1)	Protection and/or enhancement of wildlife habitat in woodland and chaparral areas.
	2)	Creation of water-oriented recreational opportunities with public access.
	3)	Creation or enhancement of fish and wildlife habitat on agricultural lands.
43	1)	Protection or improvement of water quality for designated beneficial uses in sloughs and channels in or bordering application sites.
	2)	Protection or enhancement of riparian, marsh and channel island habitats.
	3)	Protection of wintering grounds used by ducks, geese and cranes.
4	1)	Management of application system and operation to gain optimum benefit for maintenance of estuarine marsh land for wildlife.
	2)	Protection or improvement of water quality in sloughs and channels for designated beneficial uses.
21	1)	Changes in wildlife and aesthetic values that result from project implementation and the effect of these changes on the surrounding communities.
	2)	Protection or improvement in stream flow and and water quality for salmonid fishes in streams tributary to the Russian River.
	3)	Protection of water quality in Russian River for use of anadromous fishes.

Sites	Topics for Investigation
18, 28	1) Because of existing heavy recreational use, investigations would have to demonstrate that a proposed project would pose no unacceptable adverse impacts to these uses.
	2) Changes in wildlife and aesthetic values that result from project implementation and the effect of these changes on existing recreational uses and the surrounding communities.
	3) Protection or improvement in stream flow and water quality in coastal streams useful to salmonid fishes.

Site 4

Site 4 is located in Suisun Marsh in southern Solano County. It encompasses Hammond Island and part of Grizzly Island. It is bounded by Grizzly Bay, Simmons and Wheeler Island, Honker Bay and Montezuma Slough. Integrity of the land is maintained by levees and tidal gates. It is located on Grizzly Island Wildlife Area (State of California). The wildlife area is operated as both a refuge, providing food and habitat for many species of animals, and as a public hunting (waterfowl) and recreation area. The remainder of the marsh area is in private ownership for use as duck clubs or dual-purpose agriculture-duck clubs.

The Suisun Marsh (54,500 acres), which includes Site 4 (11,300 acres), constitutes about 10% of the remaining natural wetlands in California and thus is an important wintering area in the Pacific Flyway. Waterfowl populations are estimated to include 500,000 to 750,000 ducks during the peak mid-winter period. The Suisun Marsh is a particularly critical habitat during dry years when some other marsh areas are dry or of poor quality. The permanence and stability of Suisun Marsh are derived from its particular location in the Delta. The Suisun Marshes are designated as Class I premium scenic, fishery, wildlife and recreation waterways by the California Protected Waterways Plan.

Vegetation. One hundred and seventy-seven plant species were identified for the Suisun Marsh (Ref. 56). Most of these species are found in low numbers and confined to levees or high ground not normally flooded. Fifteen species were identified as covering at least 1% of the total marsh area. These species are shown below:

Species	Approximate Percentage Covered
Salt grass (Distichlis spicata)	26
Pickleweed (Salicornia virginica)	19
Alkali bulrush (Scirpus robustus)	6
Tule (S. acutus)	5
Cattail (Typha angustifolia)	5
Brass buttons (Cotula coronopifolia)	4
Fat-hen (Atriplex patula)	4
Baltic rush (Juncus balticus)	4
Cultivated barley (Hordeum vulgare)	2
Olney bulrush (Scirpus olneyi)	2
Beard grass (Polypogon monospeliensis)	2
Cultivated oats (Avena sativa)	2
Italian ryegrass (Lolium multiforum)	1
Dock (Rumex sp.)	1
Wild radish (Raphanus sativus)	1

The species listed are of particular significance in relation to the wintering duck population. Plants selected for food by ducks were alkali bulrush, of prime importance; brass buttons, secondary in use and selection; pickleweed, third in overall use; and fat-hen, wiregrass, dock, wild radish, silver-sheated knotweed (Polygonum argyrocoleon), willow weed (Polygonum lapathifolium), tules and cultivated barley, which were all selected and used by waterfowl.

The distribution and abundance of the various plant species are dependent on several factors including length of time of soil submergence, depth of submergence, amounts of soil moisture and salt, soil organic matter, and marsh salinity. Of these factors, the one which has the greatest influence on the distribution of plants is the length of time of soil submergence. A secondary factor to the selection of plant species by their tolerance for submergence is the tolerance of concentration of salts in the root zone. Tolerance to submergence separates the major marsh plants into two groups: 1) plants which can tolerate longer submergence such as alkali bulrush, narrow leaf cattail, pickleweed and brass buttons which are found in the lower areas, and 2) plants such as Baltic rush, saltgrass and fat-hen which are not as submergence tolerant and thus are found on higher marsh areas.

A secondary factor in determining plant distribution is the soil salt concentration, particularly the soil salt concentration reached during the spring and early summer when the plants are actively growing and setting seed. For alkali bulrush, the most important waterfowl food crops (seeds are eaten), salt concentrations of less than 7,000 mg/l allow the species to be outcompeted by other species, while concentrations above 24,000 mg/l inhibit seed formation. For good seed production, approximately 9,000 mg/l of total dissolved solids is preferred. Acceptable levels can be achieved if marsh soils remain submerged until mid-June from flooding during the previous fall. Submergence of the soil also prevents the regrowth of pickleweed, a major space competitor, until after alkali bulrush is established.

One plant species was identified as a rare or endangered species in Site 4:

Species	Local Habitat
(Cirsium hydrophilum) var. (hydrophilum)	Brackish marshes about Suisun Marsh

Fisheries. Striped bass and sturgeon are found in the bays adjacent to Site 4. Angler information for striped bass indicated 1,000,000 angler-day use of the bays and ocean with a yield of .3 fish/angler-day. Migration routes of salmon and steelhead are through

the bays and channels adjacent to the site. A warmwater fishery is found in the Montezuma Slough and other areas of fresh water. A partial list of warmwater fish may be found in Table II-G-3. Suisun Bay has a saltwater fishery.

The California Protected Waterways Plan classifies Suisun Marsh as Class I striped bass waters and Class I sturgeon waters. The plan also recognizes Suisun Bay as a Class I striped bass fishery.

Wildlife. Suisun Marsh is a valuable wetlands habitat. The number of private duck clubs and the presence of a state waterfowl area attest to the abundance of wintering waterfowl in this area. The adjacent bay habitat is also important as a feeding area for diving ducks and as a resting area for dabblers. Solano County ranks in the top 10 counties in California in hunter bag for ducks and geese.

The largest population of a single sport species in Suisun Marsh is pintail (duck). American widgeon, mallard, shoveler, and green-winged teal are also abundant during the wintering period. The California Protected Waterways Plan rates Suisun Marsh as a Class I inland marsh and wetland.

The Suisun Marsh and adjacent bay areas are very important shorebird, waterfowl and marsh mammal habitats. A complete list of birds and mammals, except bats, is given in Table II-G-8. Furbearers are also numerous in the marsh areas, particularly muskrat and racoon. Muskrat are taken commercially. The California rare and endangered species list includes one species which is found with Site 4:

Species	Status
(Reithrodontomys ravijventris) Salt marsh harvest mouse	Endangered

The salt marsh harvest mouse is an inhabitant of brackish and salt marshes. Much of its original habitat has been lost to bay filling and diking projects. This mouse is unusual in that is can use salt water as drinking water.

Solano County indicates that Suisun Marsh and Montezuma, Suisun and Cordelia Sloughs should be considered in the California Protected Waterways Plan.

Table II-G-8

SUISUN MARSH FAUNA 1/

BIRDS

Resident - 49 species

Pied-billed grebe (low summer populations) 2/
Great blue heron
Common egret
Snowy egret
Black-crowned night heron
American bittern
Mallard
Cinnamon teal (noticeable reduction in winter birds) 2/
Pintail
Gadwall
Shoveler
Ruddy duck 2/
Turkey vulture
White-tailed kite
Red-tailed hawk
Golden eagle (regularly transient - year round)
Marsh hawk
Kestrel
Valley quail (introduced recently)
Virginia rail
Sora rail
Black rail
Common gallinule
Coot
Killdeer
Avocet (much reduced in winter and irregular) 2/
Mourning dove
Barn owl
Great-horned owl
Burrowing owl
Short-eared owl 2/
Anna's hummingbird (possibly classed as migrant or vagrant) 2/
Belted kingfisher (winter visitor, possibly migrant) 2/
Black phoebe
Horned lark
Raven

Bushtit
Long-billed marsh wren
Mockingbird
Loggerhead shrike
Yellowthroat
Western meadowlark
Redwinged blackbird
Brewer's blackbird
House finch
American goldfinch
Rufous-sided towhee
Savannah sparrow
Song sparrow

Summer Visitor - 7 species

Black-necked stilt
Allen's hummingbird (possibly resident) 2/
Western kingbird
Barn swallow
Cliff swallow
Brown-headed cowbird
House wren (seen in late July at Joice)

Winter Visitor - 63 species

Common loon (very sporadic) 2/
Horned grebe (occasional only) 2/
Eared grebe
Western grebe (occasional only) 2/
White pelican (possibly classed as a migrant)
Double-crested cormorant (occasionally seen in summer)
Whistling swan
Canada goose
White-fronted goose
Ross' goose
Lesser snow goose
Green-winged teal
Baldpate
Wood duck
Canvasback
Redhead
Ring-necked duck
Greater scaup
Lesser scaup

Common goldeneye
Bufflehead
Surf scoter
Hooded merganser 2/
Common merganser 2/
Red-breasted merganser
Cooper's hawk
Sharp-shinned hawk (infrequent)
Rough-legged hawk
Ferruginous hawk (infrequent) 2/
Peregrine falcon (infrequent) 2/
Pigeon hawk (infrequent) 2/
Yellow rail 2/
Long-billed curlew
Greater yellowlegs
Long-billed dowitcher (possible migrant)
Common snipe (possible resident) 2/
Western sandpiper (possibly migrant)
Least sandpiper
Dunlin
Ring-billed gull
Mew gull
Herring gull
California gull
Claucous gull
Bonaparte's gull (strays noted in summer)
Yellow-shafted flicker
Red-shafted flicker
Say's phoebe
Tree swallow
Bewick's wren (status undefined, has only been observed in winter)
Robin
Hermit thrush
Ruby-crowned kinglet
Water pipit
Cedar waxwing
Northern shrike
Audubon's warbler
Tricolored blackbird 2/
Oregon junco
White-crowned sparrow
Golden-crowned sparrow
Lincoln's sparrow

Migrant - 33 species

Blue-winged teal
European widgeon
Swainson's hawk
Black-bellied plover
Semipalmated plover
Whimbrel
Marbled godwit
Lesser yellowlegs
Spotted sandpiper
Willet (seen in late July)
Pectoral sandpiper
Wilson's phalarope
Northern phalarope
Rufous hummingbird
Traill's flycatcher
Western Flycatcher
Western wood pewee
Varied thrush
Swainson't thrush
Orange-crowned warbler
Nashville warbler
Yellow warbler
Myrtle warbler
Townsend's warbler
Hermit warbler
MacGillivray's warbler
Wilson's warbler
Yellow-head blackbird
Western tanager
Black-headed grosbeak
Blue grosbeak
Vesper sparrow
Fox sparrow

Vagrants - 12 species

Red-shouldered hawk
Caspian tern
Long-eared owl
Crow
Rock wren
Prairie falcon
(sporadic winter visitor)
Summer tanager
Lesser goldfinch
Grasshopper sparrow
Purple martin
Sage thrasher
White-faced glossy ibis

MAMMALS 3/

Broad-handed mole
Suisun shrew
Ornate shrew
Racoon
Long-tailed weasel
Mink
River otter
Striped skunk
House cat
Beechey ground squirrel
Botta pocket gopher
Beaver
Red-bellied harvest mouse
California meadow mouse
Muskrat
Norway rat
House mouse
Black-tailed hare
Audubon cottontail
Gray fox (rare)
Badger
Black-tailed deer (rare-has been seen twice on Island)

NOTES:
1/ Compiled by Rolf E. Mall, California Dept. of Fish & Game
2/ Status uncertain
3/ This list does not include bats; there are 10 possible species.

Recreation. There are extremely good striped bass, salmon and steelhead fisheries surrounding the site. Some of the best duck hunting in the state occurs in the region on and about the area. Grizzly Island Wildlife Area is one of the major public hunting areas in the state. The outlying areas are in use by private hunting interests. The area is excellent for wildlife observation due to the abundance of non-game as well as game species. Both power cruising and sailing are important recreation activities in the area. The actual recreation demand in 1969 was about 44,000 user-days.

Special Considerations. The outlook for the future of Suisun Marsh will be greatly affected by salinity changes. Reduced outflow to the estuary will increase the salinity of the water surrounding the marsh. Predictions indicate that polyhaline waters of 18,000 mg/l will move upstream as far as Honker Bay. This means that for a long period each year over 75% of the marsh will be influenced by salinity levels similar to concentrations occurring now only for a short period of time on the western edge of the marsh.

Flooding of marsh lands with water of increased salinity will raise the soil salinity level. A soil salinity greater than 20,000 mg/l during the winter flooding period would mean that pickleweed would flourish to the detriment of alkali bulrush and other species selected by waterfowl for food. Mall (Ref. 60) states, "Unless alternative water supplies can be developed and supplied to the marsh system and intensive marsh management practices are undertaken, in the future only the unimportant or nonselected foods will be available to waterfowl." It is predictable that the waterfowl populations wintering at the marsh would decline in number with the decline of good feed sources. As the availability of wetlands in California is expected to decrease, the loss of any marsh land habitat would be serious.

This area provides an opportunity for the beneficial use of treated wastewater. The dilution of the encroaching salinity would maintain or perhaps enhance critical marsh vegetation such as alkali bulrush. A specific water use schedule would be required for managed marsh lands. Coordination of a constant treated wastewater application with an intermittent flooding during the fall of the year should be considered. The level of treatment of the wastewater would also be a necessary consideration.

California Fish and Game biologists, as well as many other agencies and groups, actively promote the creation, maintenance and enhancement of wetlands habitat for fish and wildlife. Present bay marsh lands offer an excellent opportunit, for the beneficial use of

treated wastewater. The expected effects of such water on marsh ecology and on recreational use should be investigated and carefully evaluated in reference to a system of application. In addition, the effects of wastewater application on water quality in the area from Antioch to San Pablo Bay would need investigation.

Site 5

This site consists of two distinct parts. The Capay Valley with Cache Creek flowing through it forms the western portion of the area. This area is in the inner coast range mountains. The second portion of Area 5 is in the Sacramento Valley and is bounded by the Capay Valley, Colusa Basin Drainage Canal, Cross Canal, Natomas East Main Drain, and, with the exception of the Woodland area which is excluded, California Highway 16. Elevations range from 30 feet in the American basin east of the Sacramento River and Yolo Bypass to 3,057 feet at Berryessa Peak and Blue Ridge.

Vegetation. The lower elevations of Capay Valley are agricultural areas, predominantly orchards. The slopes of the valley are mapped as hardwood cover type and are specifically oak grasslands. Blue Ridge is a woodland-chaparral habitat (oaks and chaparral brush). The Dunnigan hills and Sacramento Valley lands which comprise the rest of Site 5 are under cultivation or are in pasture. Predominant crops include rice, tomatoes, alfalfa, sugar beets, and tree fruits and nuts. Rare, endangered and possible extinct plants whose distributions include Site 5 are:

Species	Local Habitat	Plant Community
(Fritillaria pluriflora) Adobe lily	Adobe soil of interior foothills below 1,500 feet	Foothill woodland
(Hesperolinon breweri)	Inner coast range grassy or brush slopes, partly shaded at least partly on serpentine	Foothill woodland Chaparral
(Cordylanthus palmatus)	Alkaline overflow lands	Valley grasslands

Fisheries. The Sacramento River and Cache Creek are the two major streams included in this site. The main stem of the Sacramento River is the migration route for king salmon and steelhead. It is estimated that 260,000 king salmon spawners travel the Sacramento River with a yield of .10 fish/angler-day. Ten thousand steelhead spawn in the main stem of the Sacramento River with a yield to fishermen of .31 fish/angler-day. Striped bass and a warmwater fishery are also found

in the main stem of the river. The California Protected Waterways Plan classifies the Sacramento River as a Class I salmon, steelhead, striped bass, American shad and warmwater fisheries waters. Large and smallmouth bass are found in Cache Creek in the Capay Valley, which is classified as having a Class II warmwater fishery.

Wildlife. The inner coast range in Site 5 is a "medium grade" deer range with densities of 10-30/square mile. The Capay Valley is a problem area for deer depredation on crops and orchard lands. The rice lands are prime pheasant areas and densities range from 10-50/100 acres. The Capay Valley supports abundant populations of quail, dove and rabbits. During the winter ducks and geese feed on the Sacramento Valley farmlands. The Yolo Bypass is a concentration point for wintering waterfowl, especially after flooding occurs. The flooded Yolo Bypass and other flooded areas provide habitats for shorebirds. Tule elk range in the area adjacent to the northwest boundary of Site 5 in the Fiske Creek area. The oak-grasslands of Capay Valley are areas of abundant songbirds.

The California Protected Waterways Plan designated the Sacramento River Basin as a Class I riparian area in its extraordinary wildlife waterways evaluation. The Yolo Bypass was classified as a Class II marsh. No rare or endangered animal species are identified by the State of California as inhabiting Site 5.

Recreation. Fishing species include salmon, shad, striped bass and steelhead, and an extremely good warmwater fishery (bass, catfish, crappie, etc.) is located in the site. Game includes ducks, geese, pheasants, deer, quail, rabbits and doves. Additional activities include camping, hiking, horseback riding, picnicking, swimming and sightseeing. The Yolo Bypass offers an extremely good opportunity to provide a wildlife observation as well as hunting area due to the preponderance of shore and marsh land wildfowl and other wildlife. Actual recreational use is undetermined although it is heavy along the waterways and in Yolo Bypass.

Special Considerations. The west side of the Sacramento Valley in the vicinity of Capay Valley is dry and much land is irrigated to produce substantial crop yields. Additional water to these areas could be beneficial to agriculture and wild land features. Selective use of wastewater could be made to flood agricultural lands in the fall to attract ducks and geese. Fiske Creek is an intermittent stream just west of Site 5. Both the Bureau of Land Management and the Department of Fish and Game are cooperating to improve wildlife habitat in the Fiske Creek area. Additional waters to the area would be beneficial. The

depth and frequency of wastewater application should be investigated and evaluated for impacts on fish and wildlife.

Cache Creek (Clear Lake to the town of Capay) has been classified by the California Protected Waterways Plan as a Class II scenic, fishery, wildlife and recreational waterway. This creek should be investigated more fully to define its true value and its potential for enhancement of this value.

Site 12

Site 12 is located in southwestern Merced County and northwestern Fresno County. The Merced County portion is bounded by the Delta-Mendota Canal, Los Banos Creek Reservoir, Ortigalita Peak, and Ortigalita Ridge. The Fresno portion is bounded by the Delta-Mendota Canal, Panoche Creek and approximately the 500-foot elevation contour. Elevations range from 150 feet near the San Joaquin River near Mendota to 3,305 feet at Ortigalita Peak. The Merced County portion of the area is in the dry grassland hills of the Ortigalita area. The eastern edge of the Merced County portion and all of the Fresno County portion of the area are in the agriculture flatlands of the San Joaquin Valley. Orchards of fruit and nut trees, pasture land, and field crops of cotton, tomatoes, sugar beets, melon, etc., are found in this area.

Vegetation. Most of the land in the Fresno portion of Site 12 is classified as agricultural. There are, however, grassland areas used for pasture and alkali areas not presently suitable for agriculture which support native vegetation. The vegetation of the Merced portion of the wastewater management area is for the most part grasses and forbs on dry, rocky hills. At higher elevations the cover type is described as southern desert shrub and pinyon-juniper which is indicative of the dryness of the local area. Rare, endangered and possibly extinct plants of this area are listed in Table II-G-9.

Fisheries. The Los Banos Creek Reservoir, the Delta-Mendota Canal and the California Aqueduct all have warmwater fisheries. The California Protected Waterways Plan classifies the California Aqueduct and Delta-Mendota Canal as Class III warmwater streams and Los Banos Creek Reservoir as a Class II warmwater reservoir. These waterways are intensively used by local and other county residents for fishing sites.

Wildlife. Deer occur in the hills on the west side of the San Joaquin Valley in densities of approximately 20/square miles in the woodland-chaparral and saltbrush-buckwheat habitat types. The westside hills are excellent upland game habitats and support populations of doves, jackrabbits, cottontails, brush rabbits, pigeons, chukar and California valley quail. Quail are found in densities of 10-100/100 acres in lower elevation wild lands and densities of 10/100 acres in crop lands. The saltbrush-buckwheat habitat type supports densities up to 100/100 acres. Pheasants are confined to agricultural areas with the best habitat found in rice, cotton and sugar

Table II-G-9

RARE, ENDANGERED AND POSSIBLY EXTINCT PLANTS OF SITE 12

Species	Local Habitat	Plant Community
Merced County		
Parvisedum petandrum	Rocky places, often on serpentine 800-2500 feet Inner coast range	Openings in foothill woodland
Neostapfia colusana	About vernal rain pools	Valley grassland
Orcuttia californica	Drying mudflats	Valley grassland
O. californica var. inaequalis	---	Valley grassland
O. greenei	Moist open places	Valley grassland
O. pilosa	Vernal pools	
Monardella leucocophala	Sandy places	Valley grassland
Cordylanthus palmatus	Alkaline soil	Valley grassland
C. hispidus	Alkaline places	Valley grassland
Fresno County		
Amsinckia vernicosa var. furcata	West side San Joaquin Valley	Valley grassland
Atriplex vallicola	Dried rainpools and flats	Valley grassland
Lupinus horizontalis var. horizontalis	Dry slopes below 2000 feet Inner southern coast range	Valley grassland
Erigonum deserticola	No local data	
E. temblorense	No data	
Orcuttia greenei	Moist open places	Valley grassland
O. californica	Drying mudflats	Valley grassland
O. californica var. inaequalis		Valley grassland
Cordylanthus palmatus	Alkaline soil	Valley grassland

beet crops. Densities are usually near 50/100 acres but can be as high as 100/100 acres. Ducks and geese from adjacent marsh lands (east of the site) feed in agricultural lands within the area.

Marsh areas east of the site draw many shorebirds. Muskrats are common in unlined agricultural canals. Furbearers are common in the upland game habitats. Animals designated as rare or endangered by the State of California whose distributions included Site 12 are:

Species	Status
(Thamnophis couchi gigas) giant garter snake	Rare
(Crotaphytus wislizenii silus) blunt-nosed leopard lizard	Endangered
(Vulpes macrotis mutica) San Joaquin kit fox	Rare

The giant garter snake is confined to areas around permanent fresh water. Its habitat has been diminished by filling of sloughs and draining of marsh areas. The blunt-nosed leopard lizard inhabits dry, "...sparsely vegetative plains, alkali flats, low foothills, grasslands, canyon floors, large washes and arroyos" (Crossroads, 1971). With changing land use to agriculture, the natural habitat has been greatly diminished for this species. The San Joaquin kit fox is found in dry areas of native vegetation associated with kangaroo rats. Diminished numbers of this species are related to the import of water for irrigation and the conversion of native vegetation to agriculture.

Recreation. There is a fairly large warmwater fishery in the area. The best hunting potential involves the upland species including quail, rabbits, doves, pheasants and chukar. Ducks also feed in the eastern portion of the area.

Other activities in the site include camping, picnicking, boating, swimming and hiking. The area is generally deficient in water-oriented recreation.

Special Considerations. The agricultural areas could accommodate additional water, particularly in the drier western areas. The Ortigalita area could possibly support a different vegetative cover with the addition of water. However, additional water could affect the presently abundant upland game conditions. This effect would have to be evaluated in depth in relation to a proposed management plan.

Site 18

Site 18 is located in Marin and Sonoma Counties. The western boundary of the area is the Pacific Ocean, except in the Tomales-Point Reyes and Bodega land areas. The Russian River forms the northern boundary and Nicasio and Gallinas Valley the approximate southern boundary. The eastern boundary is defined by Green Valley Creek in the north and watershed boundaries in the middle and southern reaches (west of Petaluma and Novato). Elevations vary from sea level to 1,887 feet at Big Rock Ridge. Topography and habitats in this extensive area range from sand dunes to salt marshes and from redwood forests to salmon streams. The coastal and forested areas provide convenient recreation areas to the Bay Area communities. The Russian River has for many years been a widely used recreation area. Agriculture is a major pursuit in the area. Orchard crops, particularly apples, and dairies with their pasture lands are extensive in Site 18. The California Protected Waterways Plan designates the Russian River as a Class I premium scenic, fishery, wildlife and recreation waterway. It has also classified Tomales Bay as a Class II scenic, fishery, wildlife and recreation waterway.

Vegetation. The vegetative cover in Site 18 is highly diversified. The most extensive single cover type is grass and forbs which is found on the interior rolling hills and the coastal prairie. Orchard crops and hardwoods cover extensive areas, particularly in the vicinity of Sebastopol. Grasslands blend into hardwood, particularly oaks, and at higher elevations into chaparral. In the northern and southernmost portions of Site 18, higher elevations and some lower canyon areas are covered with coniferous forests which include redwoods. The list of rare, endangered or possibly extinct plants for this area contains 44 species (Table II-G-10). The large number of such species may be the result of the intense recreational uses that some parts of this area receive, land use changes associated with urbanization, overgrazing and many additional stresses placed on plant communities by man and his activities.

Fisheries. The streams in this area contain both anadromous and warmwater fisheries. The most important stream is the Russian River. King salmon (500 fish), silver salmon (5,000 fish) and steelhead (50,000 fish) are estimated to use the river and its tributaries. Ten thousand angler-days/year with a yield of .2 fish/angler-day for salmon and 60,000 angler-days/year with a yield of .2 fish/angler-day for steelhead indicate the recreational use of this fishery. The Russian River and its tributaries also support a warmwater fishery

Table II-G-10

RARE, ENDANGERED AND POSSIBLY EXTINCT PLANTS
OF SITE 18

Species	Local Habitat	Plant Community
Sonoma County		
Campanula californica	Near coast	Freshwater marsh
Carex albida	Open marshy places below 300 feet	Mixed evergreen forest
Rhynchospora californica	Bogs, Ledum swamp	
Arctostaphylos bakeri Stanford manzanita	Dry serpentine ridges near Camp Meeker and Occidental	
A. densiflora Sonoma manzanita	Banks, along roadside 10 miles west of Santa Rosa	
Agrostis blasdalei Bent grass	Near coast	Coastal strand (dunes) Northern coastal scrub (cliffs)
Calamagrostis bolanderi		Freshwater marsh Meadows in closed-cone pine forest Northern coastal scrub
C. crassiglumis	Swampy places	Freshwater marsh Northern coastal scrub
Lupinus abramsii	Open woods 2000-5000 feet	Mixed evergreen forest Yellow pine forest
Trifolium amoenum	Rare, in low rich fields, swales	
Fritillaria liliacea	Heavy soil, open hills and fields Near coast	Northern coastal scrub
Lilium maritimum Coast lily	Sometimes in sandy soil, usually on raised hummocks in bogs. Also in brush and woods, at low elevations	Redwood forest Northern coastal scrub Northern coniferous forest
Linnanthes vinculans	No data	
Eriogonum canium	Dry rocky slopes on shale or serpentine 1000-2000 feet	Coastal prairie

Species	Local Habitat	Plant Community
Delphinium bakeri	Low brush and fence rows, below 600 ft. Coleman Valley	Valley grassland
D. luteum	Open places on sea bluff Bodega region	Northern coastal scrub
Ceanothus gloriosus	Sandy places	Coastal strand Closed-cone pine forest Northern coastal scrub
Castilleja latifolia	Sandy places	Coastal strand Closed-cone pine forest
Marin County		
Plagiobothrys glaber	Salt and alkaline flats	Coastal salt marsh
Campanula californica	Freshwater swamp Point Reyes National Seashore	
Chaetopappa bellidiflora	Open dry rock slopes	Northern coastal scrub Coastal prairie
Streptanthus batrachopus	Serpentine outcrops, below 2000 feet Carson Ridge	Chaparral
Rhychospora californica	Bogs, Ledum swamp	
A. montana	Serpentine flats and slopes	Chaparral
A. virgata Bolinas manzanita	Brushy slopes at edge of closed-cone pine forest	Redwood forest
Agrostis aristiglumis	Diatomaceous shale West of Mt. Vision Pt. Reyes National Seashore	
Agrostis blasdalei	Dunes Cliffs	Coastal strand Northern coastal scrub
Calamagrostis crassiglumis Reed grass	Swampy places	Freshwater marsh Northern coastal scrub
Pleuropogon hooverianus	Meadows	Mixed evergreen forest

Species	Local Habitat	Plant Community
Trifolium amoenum	Rare - in low rich, fields, swales	
Fritillaria liliacea	Heavy soil, open hills and fields near coast	Northern coastal scrub Redwood forest
Lilium kelloggii	Dry rocky places or shaded deeper soil Below 3500 feet	Redwood forest Mixed evergreen forest
Lilium maritimum Coast lily	Sometimes in sandy soil, usually on raised hummocks in bogs. Also in brush and woods, at low elevation	Northern coastal scrub Northern coniferous forest
Sidalcea hickmanii ssp. viridis	Big Carson Ridge	Chaparral
Chorizanthe valida	Sandy places	Northern coastal scrub
Eriogonum caninum	Dry rocky slopes on shale or serpentine 1000-2000 feet	Coastal prairie

in the area downstream from Healdsburg. Nongame or "rough" fish are found in numbers detrimental to the anadromous and warmwater game fish in the low summer waters of the Russian River and its tributaries. The Russian River was classified by the California Protected Waterways Plan as a Class I salmon, steelhead and warmwater waterway. In the evaluation of present fisheries, the Russian River was classified as Class I for steelhead and Class II for salmon and American shad (from mouth to Healdsburg Dam).

The minor streams of Sonoma County are reported as having 34 miles of silver salmon stream, 1,000 spawners, and a .3 fish/angler-day yield, and 48 miles of steelhead streams, 4,000 spawners, and a .3 fish/angler-day yield. These data are for the coastal streams for the entire county as are the following data for all of Marin County. The minor streams of Marin County have 92 miles of silver salmon habitat, 5,000 spawners, 1,600 angler days, and a yield of .3 fish/angler-day, and 108 miles of steelhead habitat, 8,000 spawners, 3,700 angler-days and a yield of .3 fish/angler-day. Peppermill Creek, Stemple Creek and Walker Creek have anadromous runs. Nicasio Creek also has a run, as well as facilities to compensate for a dam on the stream. In the California Protected Waterways Plan, Olema, Salmon and Pine Gulch are classified as Class III steelhead rivers in the fishery waterways evaluation. Certainly there are many streams that were not evaluated for fishery potential.

Wildlife. Blacktail deer are common over the entire Marin County area in densities of 60-100/square mile in hardwood and grassland habitat types, and 30-60/square mile in other habitat types. Deer are found on the edges of urban developments. In Sonoma County the deer densities are also 30-60/square mile for most wild land types, but are only 10-30/square mile in grasslands and some agricultural areas. Feral pigs are common in the coastal forest habitats in Sonoma County.

The distribution of California valley quail encompasses all of Marin County in densities of 10-100/100 acres in grassland, woodland-grass and hardwood habitat types. Some favorable chaparral locations support population densities of 100/100 acres. Populations of California valley and mountain quail occur in Sonoma County. Coastal forests are breeding and wintering areas for band-tailed pigeons in both counties. Doves are common in woodland-grass and other habitat types in Marin County and grey squirrels are common in densities of less than 10/100 acres. Sonoma County coastal forests contain a few blue grouse.

Tidal flats, salt marsh areas and other wetlands support wintering populations of dabbling and diving ducks (Sonoma County densities of 1,000/100 acres). Tidal flats and bays such as Bodega Bay are wintering areas for black brant. Canvasback and scaup are extremely dependent on the tidal flats for feeding areas. Wood duck nest along stream and farm ponds in densities of 10/100 acres in some localities.

Shorebirds are abundant on marsh lands and tidal flats. Shore, water and sea birds can be observed on coastline and tidelands. The grassland and agriculture habitat types support white-tailed kites (Sonoma County, 1/100 acres). Ospreys and eagles are found in Marin County. Common furbearers are found in both counties.

The California Protected Waterways Plan classifies Bodega and Tomales Bays as Class I estuaries and D-Ranch Pond as a Class III freshwater pond. Estero Americano and Estero de San Antonio are Class I lagoons. The lagoon of the Russian River is designated as Class II and the lagoon of Salmon Creek as Class III. The Russian River is classified as a Class I riparian area and Atascadero Creek and Olema Creek as Class III marshes.

The California clapper rail (Rallus longirostris obsoletus), designated as endangered, and the California black rail (Laterallus Jamaicensis coturniculus) designated as rare by the State of California, are known to inhabit salt marshes. Both species, historically or recently, have used the salt marshes of Tomales Bay. Although the bay is outside the boundaries of Site 18, changes in the lands and waters east of the bay could affect the marsh habitat of these species. No animals identified as rare or endangered by the State of California have distributions which include Site 18.

Recreation. Site 18 and the surrounding areas receive heavy recreational use. Areas such as Mt. Tamalpais, Pt. Reyes, the coastal parks and the Russian River account for many thousands of users each year. Fishing includes salmon, steelhead, shad and warmwater fish. Hunting includes deer and upland game such as quail, dove and tree squirrel. Black brant are hunted in coastal areas (bays, estuaries). Other activities include camping, picnicking, swimming, boating, hiking, horseback riding and sightseeing. Site 18 provides many locales for observing wildlife, particuarly osprey, white-tailed kite, and shore, sea and land birds.

Special Considerations. The minor streams which flow to the ocean are in need of improved summer-fall stream flows. In addition

to insufficient flow, problems of the steams involve siltation, erosion and diversion of waters. Improved fisheries could be attained with additional water of acceptable quality. In some areas which are now pasture lands, truck crops could be grown by importing water. On lands which are being converted from nonirrigated orchards to vineyards, additional water is required, particularly for frost protection.

Willow Creek and Salmon Creek were both identified by Sonoma County as critical wildlife areas. Estero Americano was identified as an important bird wintering area. The coastal bays and estuaries within Site 18 are all important wildlife area. These areas, especially the beds of kelp, have delicately balanced eco-systems which are highly susceptible to man's influence. The addition of water (even of the best quality) could be detrimental to a waterway if the outlet was a coastal bay or estuary. Changes in salt concentration or composition in nearshore waters could affect the plant and animal communities. Intensive studies would need to be carried out to evaluate the effects of any water additions to streams or estuaries.

The coastline is included in the project area boundary. Any proposed use of coastline property should be thoroughly investigated to insure that adverse impacts are avoided and that public policy is fulfilled.

Site 21

Site 21 is located in Sonoma County and encompasses Knights and Alexander Valleys and their surrounding watersheds as well as the Russian River area south of Healdsburg. Both Knights and Alexander Valleys are agricultural, including orchards and vineyards with grass meadows and hardwood and coniferous forests at higher elevations. Elevations vary from approximately 200 feet on the valley floors to 4,344 feet at Mt. St. Helena.

Vegetation. Agricultural vegetation and hardwoods dominate this area. Hardwoods cover the higher elevations, separated in some cases from agricultural cover by grasses and forbs. Drier slopes are covered with chaparral cover. The hardwood cover type represents various species of oaks in several different plant communities and habitat types. Areas of hardwoods mixed with coniferous forests are found at higher elevations. In 1964, the "Calistoga fire" burned hardwood and coniferous forest areas. Regrowth areas have a brush or chaparral appearance, although part of this growth is seedling trees. Rare, endangered or possibly extinct plants whose distributions are included in Area 21 are listed in Table II-G-11.

Fisheries. The Russian River is the major year-round stream and the entire site is contained within its watershed. It is classified as a Class I premium scenic, fishery, wildlife and recreational waterway by the California Protected Waterways Plan. King salmon spawn in the larger tributaries and silver salmon in the lower parts of the drainage. Steelhead are found in most tributaries of the river. Fish numbers and fishing statistics are known for the entire length of the Russian River. Salmon provide 10,000 angler-days/year with a yield of .2 fish/angler-day. Steelhead provide 60,000 angler-days/year with a yield of .2 fish/angler-day. During the summer, tributaries become warm and fishing is limited to warmwater and nongame species. Tributaries to the Russian River are important spawning and nursery streams and are constantly threatened by a degradation in water quality.

In the California Protected Waterways Plan, the Russian River is designated as a Class I salmon and steelhead stream as well as a Class I warmwater stream. The Russian River is classified as a Class II salmon river, a Class I steelhead river, and Class II shad waters (mouth to Healdsburg Dam).

Table II-G-11

RARE, ENDANGERED AND POSSIBLY EXTINCT PLANTS OF SITE 21

Species	Local Habitat	Plant Community
Plagiobothrys strictus	Sulfur springs near Calistoga	
Strepthanthus brachiatus	No data	
S. morrisonii ssp. hirtiflorus	No data	
S. morrisonii ssp. morrisonii	No data	
Panicum thermale Panic grass	Wet saline places about hot springs	
Lupinus abramsii	Open woods 200-5000 feet	Mixed evergreen forest Yellow pine forest
Erythronium helenae	Well-watered volcanic soil and leaf mold, in brush and woods St. Helena	Chaparral Foothill woodland
Linnanthes vinculans	No data	
Navarretia plieantha	Peaty margins of Bogg's Lake	Yellow pine forest
Eriogonum kelloggii	Dry ridges 4000 feet	Yellow pine forest
Potentilla hickmanii	Rare-in marshy places at scattered stations	Foothill woodland
Lomatium repostum	Inner coast ranges Mt. St. Helena	Chaparral Closed-cone pine forest Foothill woodland

Wildlife. Black-tailed deer are found in densities of 30-60/ square mile in most forested wild land habitat types and densities of 10-30/square mile in grasslands and parts of the agricultural habitat type. Populations of California and mountain quail are found in Sonoma County. Wintering populations of band-tailed pigeons are found locally in densities of 10-100/100 acres. In 1965, 250 wild turkeys inhabited the woodland-grass habitat type in the vicinity of Cloverdale. Wood ducks breed in densities of 10/100 acres along streams and farm pond areas. Mountain lions are found in the county.

Medium densities of common furbearers are found in the area. White-tailed kites occur in the grassland and agricultural habitat types in densities of 1/100 acres. No rare or endangered species identified by the State of California are found in Site 21. Prairie falcons, mountain king snakes and ring-tailed cats are considered to be critical wildlife species that were not designated as rare or endangered, but which are seen in diminishing numbers in the Mt. St. Helena area. The Russian River is classified as a Class I inland marsh and wetland in the California Protected Waterways Plan.

Recreation. Much of Site 21 is in private ownership and not available to the public. The actual recreational use is unknown for the upland areas. Fishing includes salmon, steelhead and a warm-water fishery. Hunting in the area includes mainly deer and quail. Other activities include camping, picnicking, sightseeing, hiking and horseback riding.

The Russian River provides recreation in the form of kayaking and canoeing as well as fishing and swimming.

Special Considerations. Application of wastewater in the area must be carefully managed to protect water quality in streams and to enhance upland habitat patterns and existing scenic and aesthetic values. Any degradation of water quality in streams, especially through warming of the water, may seriously affect salmonid fishes and ultimately the recreational value of the Russian River. Changes in upland habitat character will result in displacement of existing bird and mammal populations. Certain portions of the area are noted for the natural beauty of the existing vegetation, and any change in natural vegetation would affect their recreational use and the aesthetics of the area. In consideration of fire, wastewater applications present opportunities for protection of the natural area through fire retardation and prevention. In areas where prune and other orchards are being replaced by vineyards, additional irrigation water will be needed. Supplemental water is needed during the spring for

frost protection (aerial spraying). The soils, topography and other conditions are such that the importation of water could open new areas to agriculture.

Site 27

Site 27 is located almost entirely in Monterey County with a small portion in San Benito County. The western and central parts of the area are within the Salinas River Valley with the eastern portion in the Gabilan Range. Elevations vary from 100 feet to 3,454 feet on Mt. Johnson.

Vegetation. Varying elevations and topography provide for different habitat types. Four different cover types are usually found: agriculture at the lower elevations (Salinas Valley), grasses and forbs, chaparral and hardwoods at the higher elevations. Rare, endangered or possibly extinct plants of Site 27 are listed in Table II-G-12.

Fisheries. The Salinas River is a minor steelhead stream. It is estimated that 500 spawners use it annually and that 600 angler-days are spent at the river with a yield of .06 fish/angler-day. Low water and shifting sand in the stream bottom make it a poor habitat. The Salinas River also contains a warmwater fishery.

Wildlife. Black-tail deer are found throughout the area except for the agricultural area of the Salinas Valley. The highest densities of deer, 30-60/square mile, are found in the woodland-grass habitat type with other habitats having densities of 10-30/square mile. Wild pigs are found within the area and are considered a game animal as well as a source of depredation to agriculture in the Salinas Valley.

California valley quail are found in densities of 50-100/100 acres in woodland-grass, riparian and some agricultural habitats. Densities of 10-50/100 acres are found in chaparral and other habitats. Cottontail and brush rabbits are found in densities of 10-100/100 acres in the same area as the quail. Doves are also found within the area in breeding and hunting densities of 10-100/100 acres. Pheasants are found in densities of less than 10/100 acres in agricultural and riparian habitats. Band-tailed pigeons are found within the site.

Waterfowl are found in densities of 10/100 acres in the lower Salinas River and on farm ponds. The site is not a concentration area for waterfowl and geese are not seen.

Mountain lions occur widely in deer habitats. Raptors are common and golden eagles, osprey and white-tailed kites occur in this area.

Table II-G-12

RARE, ENDANGERED AND POSSIBLY EXTINCT PLANTS OF SITE 27

Species	Local Habitat	Plant Community
Amsinckia grandiflora	Inner coast range and adjacent valleys	Valley grassland
Campanula californica	Near coast Point Reyes National Seashore	Freshwater swamp
Chaetopappa bellidiflora	Open dry rock slopes	Northern coastal scrub Coastal prairie
Parvisedum pentandrum	Rocky places, often on serpentine 800-2500 feet Inner coast range	Openings in foothill woodland Chaparral
Tropidocarpum capparideum	Alkaline low hills below 500 feet	Valley grassland
Arctostaphylos hooveri	No data	
A. montereyensis	No data	
A. pumila Dune manzanita	Sandhills and woods	Closed-cone pine forest Northern coastal scrub
Monardella benitensis	No data	
Trifolium trichocalyx	Sandy places	Closed-cone pine forest
Fritillaria liliacea	Heavy soil, open hills and fields near coast	Northern coastal scrub Redwood forest
F. viridea Checker lily	Mostly in brush and among oaks and pines, below 2500 feet	Northern coastal scrub Mixed evergreen forest Chaparral Foothill woodland Yellow pine forest
Malacothamnus abbottii	Among willows, Salinas River	
Ophiglossum californicum Adder's tongue fern	Vernal pools	
Eriastrum virgatum	Sandy places Pinnacles National Monument	Coastal strand

Species	Local Habitat	Plant Community
Eriogonum butterworthianum	No data	Chaparral
E. nortonii	Dry rocky slopes 1500-4000 feet Inner coast range	
E. temblorense	No data	
Polygonum montereyense	Dry hard clay	
Delphinium hutchinsonae	No data	
Ceanothus rigidus California lilac	Sandy hills and flats Monterey Peninsula	Closed-cone pine forest Northern coastal strand
C. rigidus var. albus California lilac	Monterey Peninsula	
Potentilla hickmanii	Rare, in marshy places at scattered stations	Foothill woodland
Galium californicum ssp. luciense	Open hills and woods below 3500 feet Coast ranges	Redwood forest Closed-cone pine forest Mixed evergreen forest
Galium hardhamiae	No data	
Castilleja latifolia	Sandy places	Coastal strand Closed-cone pine forest
Cordylanthus littoralis	Monterey	Back of coastal strand Closed-cone pine forest

No rare or endangered animals have been identified by the State of California in Site 27. The endangered California clapper rail (Rallus longirostris obsoletus) is found in the salt marshes of nearby Elkhorn Slough and the rare California black rail (Laterallus jamaicensis coturniculus) is also believed to be in the vicinity of Monterey Bay.

The California Protected Waterways Plan designates the Salinas River as a Class I riparian land.

Recreation. There is a slight amount of steelhead fishing in the Salinas River. There is a wide variety of hunting available in the area, including deer, quail, rabbits and doves. Of special note is the existence of wild pig hunting in the area. Under proper management, pheasants could occur in densities capable of supporting hunting in this area. The area supports camping, hiking, picnicking, sightseeing and horseback riding.

Special Considerations. Treated return flow from wastewater applications could improve the flow of the Salinas River. The steelhead fishery is poor due to the low water and shifting sand in the stream bottom. With increased flow a better steelhead fishery could be produced. Detailed investigations of the effect of additional water to riparian, estuarine and bay plant and animal communities would be needed, and the quality of the water would be of major significance to any investigation. Additional water would also find uses in agriculture in the Salinas Valley. Applications of water to wildlife habitats would change these areas and thereby affect wildlife species in the wooded areas.

Site 28

Site 28 is located within San Mateo County. It includes the western slope, from the crest to the ocean, of the Santa Cruz Mountains from south of Half Moon Bay to approximately the San Mateo-Santa Cruz County line. Elevations range from sea level to 2,191 feet.

Vegetation. The vegetative cover types include pasturage and crop agriculture in a coastal band at the lower elevations, grasses and forbs in foothill areas, chaparral on dry slopes, hardwoods in some areas along the crest of hills and coniferous forests at the higher elevations in two different locations. These coniferous areas include Douglas fir, coast redwood, tan bark oak, etc., which characterize the coastal forest habitat. Rare, endangered and possibly extinct plants whose distributions include Site 28 are listed in Table II-G-13.

Fisheries. San Mateo County contains 4 miles of silver salmon streams (1,000 spawners) and 111 miles of steelhead streams (8,000 spawners) in the western slope streams which flow to the ocean. Salmon provide 1,400 angler-days/year with a yield of .14 fish/angler-day and 3,500 angler-days/year are spent on steelhead with a yield of .11 fish/angler-day. A warmwater fishery is also present in the site. The lower reaches of coastal streams are silted from accelerated soil erosion associated with disturbances to the soil mantle. Agriculture appropriates much of the water from streams, limiting nursery capacities for anadromous fishes and a summer fishery. The California Protected Waterways Plan designated Pescadero Creek as a Class III steelhead river.

Wildlife. Black-tailed deer inhabit the coast sagebrush habitat type in densities of 60-100/square mile, while other wild land habitats carry densities of 30-60/square mile. California valley quail occur in densities of 30-50/100 acres in most wild land and agriculture habitat types. Wintering densities of 10-100/100 acres are known for band-tailed pigeons. Doves, rabbits and tree squirrels are common. A single species, noted below, known to occur in Site 28 has been classified as rare or endangered by the State of California.

Species	Status
(Thamophis sirtalis tetrataenia) San Francisco garter snake	Endangered

The San Francisco garter snake inhabits marshy areas and is most

Table II-G-13

RARE, ENDANGERED AND POSSIBLY EXTINCT PLANTS OF SITE 28

Species	Local Habitat	Plant Community
Chaetopappa bellidiflora	Open dry rock slopes	Northern coastal scrub Coastal prairie
Helianthella castanea	Grassy hillsides 500-4000 feet	Foothill woodland Valley grassland
Cupressus abramsiana Santa Cruz cypress	Dry slopes 1600-2500 feet Bonnie Doon Eagle Rocks Santa Cruz Mountains	Yellow pine forest Closed-cone pine forest
Arctostaphylos pacifica	No data	Foothill woodland
Potentilla hickmanii	Rare in marshy places at scattered locations	
Castilleja latifolia	Sandy places	Coastal strand Closed-cone pine forest

commonly found in vegetation that borders ponds and lakes. Loss of habitat to housing and highway construction have reduced the population to the endangered level.

The California Protected Waterways Plan designated Pescadero Marsh as a Class I lagoon. Class III lagoons include Gazos Creek, Pomponio Creek, San Gregario Creek and Tunitas Creek.

Recreation. Recreational use along the coast and in state parks is heavy. There is a moderate amount of salmon and steelhead fishing in the area as well as a warmwater fishery. The available hunting includes deer, quail, doves, rabbits and tree squirrels. Other activities supported by the site include camping, picnicking, swimming, hiking, sightseeing, horseback riding and wildlife observation.

Special Considerations. Imported water may have streamflow augmentation uses in this area, particularly where agricultural appropriation of stream waters has diminished the salmonid or warmwater fisheries through streamflow depletion. The effect of additional water on riparian, marsh and estuarine communities would need extensive investigation before any decision could be made on the advisability of adding wastewater to the present stream system either directly or by subsurface flow.

Site 42

Site 42 is in Contra Costa County and encompasses an area from the summit of Mt. Diablo eastward to Clifton Court on Old River (San Joaquin River). The northern boundary is south of the Bay and Delta front cities. It contains in its easternmost reaches sections of the California Aqueduct and Delta-Mendota Canal and the Clifton Court Forebay. The elevation ranges from 3,849 feet at Mt. Diablo to near sea level at the edge of the San Joaquin Delta and valley.

The area is characterized by several valleys sloping from west to east that are separated by ridges 500 to 1,000 feet in elevation. The valleys and lower hills are in agriculture or pastures. The streamflows in these areas are intermittent and the channels are highly eroded due to the movements of cattle. Wild land areas exist along the higher ridges and in canyons that lead from the valleys to Mt. Diablo. These areas are typified by hardwoods and chaparral. Along the lower eastern edge of the area, which is relatively flat, there are orchards and row crops. The area contains about 500 acres of alkaline and nonproductive soils. Although there is hunting at the higher elevations and warmwater fishing in Marsh Creek Reservoir, the area is generally considered of low productivity for these wild land uses.

Vegetation. The vegetative cover varies from orchards, crops and grasses at lower elevations to woodland-grass at median elevations and hardwood and chaparral at high elevations. The wide range of elevations and topography provides the opportunity for a number of different plant communities. Most of the low slope lands are in grass or grass and oak. Rare, endangered or possibly extinct plants in Site 42 are listed in Table II-G-14.

Fisheries. A warmwater fishery is present in both the California Aqueduct and the Delta-Mendota Canal. These two canals are designated as Class III warmwater fisheries in the California Protected Waterways Plan. Marsh Creek and Contra Loma Reservoir south of the City of Antioch and Clifton Court Forebay contain warmwater fisheries. Stream flows at lower elevations are intermittent. Due to its marginal use for fish and wildlife, the fishery in the area is poorly defined.

Wildlife. Black-tailed deer are found in densities of 10-30/ square mile in woodland-grass and chaparral habitat types. Deer are also found on some agricultural lands adjacent to wild areas and pose

Table II-G-14

RARE, ENDANGERED AND POSSIBLY EXTINCT PLANTS OF SITE 42

Species	Local Habitat	Plant Community
Amsinckia grandiflora	Inner coast Range and adjacent valleys	Valley grassland
Eriophyllum jepsonii	Dry rocky, often serpentine slopes 1000-3000 feet Inner coast range	Foothill woodland
Heliantheila castanea	Grassy hillsides 500-4000 feet Mt. Diablo State Park	Valley grassland Foothill woodland
Parvisedum pentandrum	Rocky places, often on serpentine 800-2500 feet Inner coast range	Opening in foothill woodland Chaparral
Streptanthus hispidus	Talus, rocky outcrops 2000-3850 feet Mt. Diablo State Park	Chaparral
Tropidocarpum capparideum	Alkaline low hills, below 500 feet, in region about the foot of Mt. Diablo	Valley grasslands
Arctostaphylos auriculata	Dry slopes of sandstone 500-2000 feet Mt. Diablo State Park	Chaparral
Phacelia phacelioides	Uncommon, in rocky places, 2000-3500 feet Inner coast ranges Mt. Diablo	
Calochortus pulchellus	Frequent on wooded and brush slopes Above 700 feet Mt. Diablo	Foothill woodland Chaparral
Fritillaria liliacea	Heavy soil, open hills and fields near coast	Northern coastal scrub Redwood forest

Species	Local Habitat	Plant Community
Hesperolinon breweri	Grassy or brushy slopes, partly shaded on serpentine Inner coast range 400-3300 feet Mt. Diablo	Chaparral Foothill woodland
Hibiscus californicus	Moist banks Lower Sacramento and San Joaquin Rivers	Freshwater marsh
Eriogonum truncatum	Dry slopes 1000-1500 feet East base of Mt. Diablo	Edge of chaparral
Corhylanthus nidularius	Serpentine slopes 2000 feet Near Deer Flat Mt. Diablo	Chaparral
Sanicula saxatilis	3000-3800 feet Mt. Diablo	Chaparral Foothill woodland

a continuing depredation problem in home gardens and on crop lands.

California valley quail are found in densities of 10-50/100 acres in the chaparral and part of the agricultural habitat types. Doves are found in the woodland-grass and agricultural habitat types in densities of 10-100/100 acres. Jackrabbits, cottontails and brush rabbits are common in wild lands and farming areas. Pheasants are confined to the agricultural habitats, especially cereal crops, in densities of 10-50/100 acres. Band-tailed pigeons are common winter migrants in the woodland-grass habitat, particularly around Mt. Diablo, in densities of 10-100/100 acres.

Songbirds are numerous in the woodland-grass and chaparral habitats. Golden eagles are occasionally seen in the Mt. Diablo area. Marshes have abundant populations of waterbirds. Animals designated as rare or endangered by the State of California include:

Species	Status
(Masticophis lateralis euryxanthus) Alameda striped racer	Rare
(Thamnophis couchi gigas) giant garter snake	Rare

The Alameda striped racer is usually associated with chaparral, but also occurs in grasslands, woods and on rocky slopes. The loss of habitat due to construction and development has reduced the numbers of this species. The giant garter snake is confined to areas around permanent fresh water and has been reduced in number by the filling of sloughs, the draining of marshes and other land use changes.

Recreation. Actual recreation in the site is undefined but is considered limited because of limited public access.

The fishing in this area consists of warmwater species, mainly bass, catfish and crappie in the reservoirs. The hunting includes deer, quail, doves and rabbits. Hiking and horseback riding sites are available in this area. Also found in this area is camping, picnicking, boating and swimming.

The marsh land and foothill land offer good opportunities for wildlife and habitat observation. Caves and caverns on this site might offer unique recreation for Bay Area residents.

Special Considerations. Good fish and wildlife habitats are scarce in the area due in a large part to arid conditions and present land uses. Use of the higher elevations for wastewater disposal would alter the wild land remaining in the district, but wastewater disposal may enhance wildlife if proper management of the area is exercised.

Special attention should be given to the enhancement of existing wild land systems and to the creation of nature parks and recreational fisheries because of the proximity to sources of recreational users.

Site 43

Site 43 is located in San Joaquin County southwest of Stockton and encompasses Union and Robert's Islands. This area of the Delta is generally bounded and intersected by channels of the San Joaquin River and various canals. Much of the land is at or below sea level and was claimed from tidal marsh lands. It is now maintained for agricultural purposes by levees and pump-out drainage systems. Water systems in the area are a complex of freshwater tidal channels that vary seasonally in response to flooding and pumping schedules at the federal and state pumps near Tracy. During most of the year flows along the east and south sides of the area have relatively high total dissolved solids that are contributed by the San Joaquin River. The Sacramento River water which is transferred across the Delta by the Central Valley and California Water Projects has lower total dissolved solids concentrations and is used along the north and west sides of the site. Water quality conditions in the San Joaquin River may be considered poor in the vicinity of Stockton during late summer because of depressed levels of dissolved oxygen. Water quality is otherwise good to excellent although the water is turbid.

The Delta contains important fish, wildlife and recreational areas. The site has a valuable striped bass and warmwater fishery, it is a necessary spawning area and migratory route for anadromous fish, it provides extensive native riparian habitat for a great diversity of birds and mammals, there are fallow agricultural lands that are necessary wintering grounds for waterfowl and it is heavily utilized for recreation for a variety of purposes. The Delta is classified as a Class I premium scenic, fishery, wildlife and recreational waterway in the California Protected Waterways Plan. In summary, it is one of the most complex and valuable fish and wildlife areas in the state. It is also the most intensively studied area in California in regard to its aquatic resources.

Vegetation. The area is agricultural and is principally used for grains, although asparagus is an important luxury crop. A large but undetermined percentage of the land is cultivated. Soils are peat with sand and loam. Natural plant communities are an important component of the area. Native vegetation is found in the riparian habitat along the channels, sloughs, berms and channel islands. Most of the native vegetation is on levees with the type and extent dependent in part on the age of the levee and current levee maintenance practices. Conditions may vary from bare earth, grass and rock to luxuriant growths of large hardwood trees, brush and

blackberry brambles. Berms near levees or in channels form extensive tule and cattail marshes. Channel islands are probably more ecologically complex in their vegetative makeup than the levees because of the variety of stages in island evolution and vegetative succession. Because of the variety and importance to wildlife of native vegetative habitat in Site 43, any location proposed for wastewater application should be investigated for its ecological value to the surrounding land.

Several plant species reported in the area are listed as rare or endangered and are noted below:

Species	Local Habitat	Plant Community
(Cirsium crassicaule)	Shallow water, wet places in fields near San Joaquin River	
(Orcuttia greenei)	Moist open places	Valley grassland
(Eryugium racemosum)	Low wet places below 100 feet	Freshwater marsh

Fishery. Site 43 is a part of the migratory route of anadromous fishes, most notably king salmon, into the San Joaquin River system. These runs of fish have been endangered in recent years by low flow and poor water quality near Stockton during the autumn migrations. In addition, young salmonids migrating downstream in the spring are pulled into the pumping stations situated along their routes. Striped bass spawn in the area, although it is not recognized as one of the prime spawning areas because of poorer water quality conditions. Young fish rely on the area as a nursery because of its richness in zooplankton. As are the salmonids, many small fishes of all species are pulled into the pumps while some are screened out of the water and subsequently released near Antioch. Most of the anadromous and warmwater fishes of California use the Delta and Site 43. There is an important fishery in the area for striped bass, catfish, largemouth bass and crappie.

Dredging, changes in water quality and pumping-induced stream flows affect fisheries in the site. Dredge spoils may blanket important wildlands. Domestic wastes and agricultural return waters affect the survival of some runs of salmon and steelhead and in general degrade the productivity of the area for game fish. Pumping-

induced stream flows influence water quality, fishery productivity and fish migrations in the study area.

The California Protected Waterways Plan classifies the Sacramento-San Joaquin Delta as a Class I striped bass and sturgeon fishery. The lower San Joaquin and associated sloughs are also listed as a Class I warmwater fishery. The San Joaquin River is also classified as a Class II salmon river and as Class III for American shad (in "good" water years, from the mouth of the river upstream to the Merced River).

Wildlife. The vegetation on the levees in the Sacramento-San Joaquin Delta provides, den, nesting and cover requirements for over 100 wildlife species. The narrow riparian habitat supports an inordinate number of species as well as populations of individuals. River otter, muskrat, raccoon and opossum are examples of resident mammals. Many migratory and resident birds depend upon the levee vegetation for shelter and the agricultural areas for food, while others may carry out their entire life cycle in the riparian habitat. Fallow grain fields are important feeding and loafing areas for ducks, geese and cranes during the winter. The non-leveed channel islands (unreclaimed) with their dense vegetation of tules, brush and trees provide the highest quality of nesting, roosting and escape cover in the Delta for many species of wildlife, including perching birds, wading birds, marsh birds, birds of prey and water-associated rodents and furbearers. These channel island areas are also the most aesthetically pleasing areas in the Delta.

The Delta Master Recreation Plan (Ref. 51) recommends that "all of the channel islands and adjacent levees in that portion of Old River bounded by Coney and Union Island" be designated as a "Fish and Wildlife Area". Other waterways within Site 43 are designated as "protected use" or "natural use" areas.

The Delta area is a particularly good wildlife area. Of special importance is hunting for pheasants and waterfowl. San Joaquin County rates in the top ten counties in the state for hunter bag of pheasants, doves and jackrabbits. Valley quail are numerous along the Delta levees where good cover vegetation remains.

The Delta waterways and adjacent farming lands are important wintering areas for waterfowl. Sandhill cranes may occasionally use the area. The county rates in the top ten in hunter bag for ducks and geese.

The Delta waterways support a large number and variety of birds and mammals. The Delta islands support breeding pairs of the rare white-tailed kite along with many raptors and songbirds. River otter are common and muskrat are numerous. There is commercial trapping for muskrat and mink. Delta waterways also support beaver.

Animals classified as rare or endangered by the State of California are:

Species	Status
(Thamnophis couchi gigas) giant garter snake	Rare
(Coccyzus americanus occidentalis) California yellow-billed cuckoo	Rare

The giant garter snake is confined to areas around permanent fresh water and has been reduced in number by the loss of habitats when sloughs are filled or marsh areas drained. The California yellow-billed cuckoo inhabits dense streamside vegetation and has also been reduced in numbers and range by loss of habitats to agricultural and urban developments.

Recreation. The area supports an excellent fishery including striped bass, salmon and sturgeon. Excellent warmwater fishing for catfish and largemouth bass is also available.

Good duck and pheasant hunting is found in the area as well as hunting for doves, rabbits and quail.

Of special note in the area are the uncommonly fine opportunities for wildlife observation, nature walks, water skiing and boat trips. This area represents a rare and valuable marsh land and riparian habitat which is unique in both its quality and scope. The proximity of this area to three major population centers indicates an opportunity to provide a high quality natural area for a large number of potential users. A large amount of recreation is provided by commercial facilities.

Special Considerations. Of outstanding importance to the ecology of the area are those locations containing natural or uncultivated vegetation. Most of this habitat is on levees, islands and berms along with some marsh land. Although waterfowl use the open fields in winter, almost all of the wildlife species are dependent to

some extent on the natural habitats. The effects of wastewater applications on natural habitats located on the levees, berms, islands, or marshes must be evaluated in terms of ecological values and public desires. Because these nonagricultural habitats are in relatively short supply in the Delta as compared to crop land, their status is a special concern. Of specific concern are the non-leveed channel islands. The Department of Fish and Game indicates that these areas should be preserved in their "natural" condition. These areas are prime habitats for white-tailed kite, waterfowl and many other animals. The maintenance of the vegetative habitat of the islands as well as the riparian habitat of the levees, berms and marshes is considered of primary importance.

Consideration should also be given to potential changes in water quality and the aquatic environment. Water quality in the San Joaquin River from Moss Landing to Turner Cut, which borders on part of the study area, currently is less than desirable. Degradation is mainly caused by excessively high salt content, nutrients and organic loading. During low flow periods most of this water is mixed with Sacramento River water and transported south via the Delta-Mendota Canal and the California Aqueduct. Thus, the quality of water along the west side of the project area is decidely better than in the San Joaquin and Old River channels.

Water quality in dead-end sloughs can vary and is better at the open end. Such characteristics affect the usefulness of these sloughs for fishing.

Water quality in the main channels may limit fish behavior, productivity and reproduction. Low levels of dissolved oxygen that occur in the San Joaquin River have caused fish kills. The high level of total dissolved solids is thought to inhibit the spawning of striped bass. Poor water quality and insufficient flows in the San Joaquin River inhibit the migrations of salmon and steelhead.

Changes in native riparian habitats, water quality, wintertime use of fields by waterfowl and recreational access and uses should be studied for potential projects.

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